

condenser, B the eduction pipe, C the air pump, D the cold water cistern in which they are immersed; E is the injection valve, a conical valve rising a little above the bottom of the condenser, with a perforated cap below in the cold water cistern; this valve is lifted by the screwed rod F, and the admission of the injection water can be regulated with the greatest accuracy by the screw.

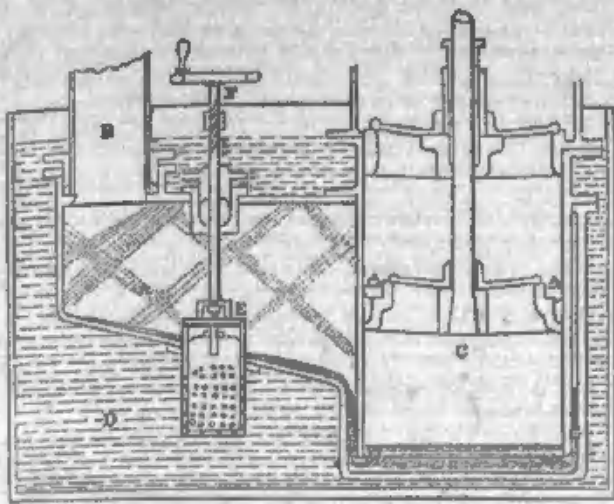


FIG. 5.

The water enters the condenser in a fine sheet all round the valve, which strikes the sides of the condenser and fills the whole space with a fine spray; he had ascertained this by trying the valve in a box similar to the condenser, but partially open, with a column of water of the same pressure as the injection, and he found the distribution of the water was so perfect as to fill the box with a complete spray or fog. There was also a different construction in the air-pump which he considered advantageous; the bottom dropped into a well G G, in the bottom of the condenser, and the water rose up the space G G, when the air-pump bucket dipped into it, forming a water-valve instead of the ordinary foot-valve, and giving pressure enough to ensure the bucket-valve opening, if there was any obstruction. An indicator figure, taken from the engine when in full work, at 24 revolutions per minute, driving shafting and two fans, indicated 72½-horse power. By an indicator figure of the same engine when part of the work was thrown off, it amounted to 38½-horse power; and by another indicator figure for the engine and four lines of shafting alone, without any work, amounted to 14 horse-power, at the same speed of 24 revolutions per minute. The engine is high-pressure, expansive and condensing, and is one of a pair working coupled together; there was originally in their place, a pair of high-pressure engines, non-expansive and non-condensing, and the comparative economy of power effected by the present engines is so great, that although the same boilers only are used, there is 2½ to 2½ times the power obtained. The indicator figures exhibited by Mr. Cowper to the meeting, were drawn to the scale of 20 inches length of stroke, and ¼-inch for each lb. of pressure; and he begged to suggest that scale as a convenient one to be adhered to, for indicator figures intended to be exhibited to the Institution.

Mr. SLATE thought the plan of injection proposed by Mr. Cowper, was a very eligible one. With reference to the alternate injection of the water, he had experienced the difficulty in marine engines, of too much water being admitted by the injection cock, whenever the engines were working slowly, causing the injection water to choke up the condenser, and even get up into the cylinder, and he had adopted a slide valve in the injection pipe, admitting only water enough at each stroke of the engine for the condensation of the steam; the jet of water was thrown against a perforated distributing plate.

Mr. MCCONNELL remarked that, there would be a tendency in the rose of the injection pipe, as adopted by Mr. Smith, to become choked up.

Mr. COWPER observed that in the plan he had described, that difficulty was quite obviated, as in the case of the circular valve becoming choked, they had only to lift it up an inch or two by the screw handle, and then screw it down again, and the rush of water would effectually wash out any obstruction.

Mr. MCCONNELL considered that a great advantage, as it would

prevent any stoppage of the engine. He thought the members of the Institution were much indebted to Mr. Smith for his researches, but their obligations were small compared with those of the iron manufacturers of the district, with whom he had been more immediately brought in contact, as the saving proved to have been effected by the improvement of the engines, formed so serious a proportion to the whole expense of working them. It was important that this subject should occupy the attention of the iron masters, because their material must bear a proportion in its price to the management bestowed in its manufacture. He hoped Mr. Smith would not lose sight of the subject, but keep it prominently before, not only the iron manufacturers of South Staffordshire, but the owners of steam-engines throughout the country; and he thought this Institution was an excellent vehicle for the purpose, because it was only by such an Institution that information could be collected in a practical form, and the results be duly investigated and considered. In conclusion, he proposed a vote of thanks to Mr. Smith, which was passed.

BLOWING ENGINES.

(With Engravings, Plate X.)

On a Blowing Engine working at High Velocities. By ALBERT SLATE, of Dudley.—(Paper read at the Institution of Mechanical Engineers).

Mr. SLATE directed attention to the various changes through which this description of engine has passed, the better to elucidate the difficulties to be overcome, and the advantages to be derived from the further change now proposed.

The first records he has been able to collect show the blowing cylinders to be single-acting, or having the power of propelling the blast when the piston was moving in one direction only; three or more of these blowing cylinders appear to have been attached to one crank-shaft, worked by a water wheel, and thus a tolerably steady pressure of air has been obtained. When the gradual improvements of the steam-engine and the demand for increased means of manufacture caused it almost entirely to supersede all other power, the blowing apparatus appears to have been accommodated as much as possible to the steam-engine, so as to afford the character of engine for the time being, the fullest development of its power.

In pursuance of this object, the single-acting atmospheric engine of Newcomen was attached to a blowing cylinder, which propelled the air from the upper side of the piston only, and in addition to the water regulator, which appears to have been known at an earlier date, there was attached a cylinder, now known as the regulating-tub, which was equal to or larger in diameter than the blowing cylinder. In this was fitted a piston with a rod moving in a guide fixed on the open top of the regulating tub, the bottom of the latter being close, and having an open connection to the main from the blowing cylinder. The piston in the tub was loaded to the pressure of blast required, and in the intervals between the discharges of the blowing cylinder, the descent of the piston in the tub kept up the discharge of air into the water regulator, which intervened between it and the furnace; thus in effect, as far as possible, making the engine double-acting. To prevent the piston being blown out of the regulating tub, a large safety-valve was attached to the top of the rod by a strap, long enough to allow the desired play of the piston, and short enough to lift the safety-valve, or snorter, as it is usually termed, if the piston at any time exceeded its limits; and the number of strokes of the engine were also regulated by the tub piston, as to it the catenacts were attached.

When the double-acting engines of Watt were introduced, the regulating tub was still retained, though not nearly so essential a part of the machine as in the former instance.

The next change that took place was the general abandonment of the water regulator (though some of these are still at work, or have been within a few years); the reason for this change was the discovery that the air in summer, already surcharged with moisture, took up an additional quantity from passing over the surface of the water in the regulator, and that this was prejudicial to the working of the furnaces.

When the large area of the water regulator was shut off, it was then found that the tub was by no means such a perfect regulator as it was supposed to be, as the momentum of the engine passed too sudden into the heavy piston of the tub, and throwing it up

much beyond the height due to the pressure of the air, caused an irregularity that was even more aggravated by its descent; to counteract this, a spring beam was placed on the top of the tub so as gradually to check the momentum of the piston, and this had some effect, but not at all a satisfactory one.

The next alteration which appears to have suggested itself, was the application of large air chambers, from twelve times to thirty times the area of the blowing cylinder, in which the elasticity of the compressed air acted as the regulator of the discharge, the tub with its piston being in some cases retained to work the catanets, and as a tell-tale against the engine men, in case of their allowing the steam to slacken and the piston to descend.

We now enter upon the last change which took place some fifteen years ago, namely, the coupling of two double-acting engines, and double-acting blowing cylinders upon the same crank-shaft at right angles, so as to keep up a regular discharge. This effect was in some measure obtained, but an air chamber, or, what is equivalent to it, very large mains, were still required to obtain what was considered a satisfactory result.

At this point the realised improvements of the blowing engine stop short, leaving it still a large cumbersome and expensive machine, and not capable of moving through its valves the highly elastic medium air, at a greater rate than the absolutely non-elastic fluid water, is moved through an ordinary pump. Under these circumstances, it must be obvious that after all the engineering talent that has been spent on this description of engine, there is still (if the expression may be applied) a wide range of discovery open.

The immediate cause of the writer's attention being attracted to the improvement of the blowing engine, was the difficulty experienced in regulating one of the old construction of blowing engines in the latter part of 1848, and having at the same time occasion to employ some small 8-inch cylinders driven by the air of the large blowing engine. These small cylinders when driving the shafting only, sometimes attained a velocity of upwards of 200 revolutions per minute, suggesting the idea of the possibility of reversing their motion and taking in the air in place of blowing it out through them; there was however a difficulty in the slide valve which did not open and shut fast enough. After some consideration it was agreed that another cylinder should be prepared, and the centre port made much larger, and the slide overtravelled nearly half its stroke in excess, which had the desired effect; a cylinder of 9 inches diameter, and 1 foot stroke, having been driven 320 revolutions or 640 feet per minute, discharging the air at a pressure of $3\frac{1}{2}$ lb. per square inch, through a tuyere of $1\frac{1}{2}$ inch diameter, or $\frac{1}{16}$ th of the area of the blowing piston. This performance, as is well known, is more than double that of any ordinary engine, the total area of the tuyeres with a 30 inch blowing cylinder, being at a pressure of $3\frac{1}{2}$ lb., about 52 circular inches, or $\frac{1}{16}$ th of the area blowing piston.

We are all acquainted with the tremour which is felt even in the best form of the large sized engines; but in the experiments at a high velocity with the small sized cylinders, not the slightest jar was felt or noise heard, it is therefore proposed to increase the speed of the piston in actual practice, from 640 to 750 feet per minute, the length of stroke being 2 feet in place of 1 foot; this is somewhat under the speed of a locomotive piston at 40 miles per hour, which is about 800 feet per minute, so that it is conceived no difficulty can present itself to this. The proposed speed of 750 feet per minute, is three times the usual speed of the present blowing engines, 250 feet per minute.

The construction of the proposed engine is shown in the accompanying engraving, fig. 4, Plate X., showing the plan of a pair of horizontal steam cylinders and blowing cylinders; AA are the steam cylinders, 10 inches diameter and 2 feet stroke; BB, the blowing cylinders, 30 inches diameter and 2 feet stroke, with their pistons C, fixed on the same piston rods D, which are connected to two cranks E, fixed at right angles to each other on the same shaft. The slide valves F, of the steam cylinders are worked by the eccentrics G, on the cranked shaft, and the cranks H, at the outer ends of the same shaft, work the slide valves I, of the blowing cylinders. The centre port K, passes downwards to an external opening for the admission of the air, and the discharge ports LL, deliver into the passages M, on the top of the cylinder, which communicate with the air main N, by the chest O, formed between the cylinders. The piston of the blowing cylinder is intended to be made without any packing, being a light hollow cast-iron piston turned to an easy fit; and the slide valve of the blowing cylinder to have a packing plate at the back, working against the cover of the valve box, with a ring of indiarubber inserted between this plate and the back of the valve, to give a little elasticity.

It appears that 30 inches diameter is somewhere about the most convenient size for a stroke of 2 feet, and as it is considered an advantage to have the stroke as short as possible, to increase the regularity of the blast, the comparative cost of the different engines which follows has been taken upon this basis two 10-inch steam cylinders and two 30-inch blowing cylinders, costing together (exclusive of the boilers,) about 400*l*., being reckoned equal to blow one of our largest furnaces, making 100 tons of iron per week, and having a surplus equal to blowing a cupola or refinery, as is generally allowed, as such an engine would give at 640 feet per minute the same speed of piston as in the experiments, very nearly 30 circular inches of tuyere, at a pressure of $3\frac{1}{2}$ lb. to the square inch; the circular inch is used in speaking of the area of tuyere, as the blast that any furnace is taking is usually reckoned by simply squaring the diameter of the tuyere, but the pressure is taken on the square inch.

The experiments on which these calculations were founded, having been made upwards of 12 months ago, were repeated last week, and the results were found to be as nearly as they could be measured the same, the blowing cylinder had in the interval been driving the lathes in the pattern shop, and the slide was found perfect. An indicator was applied with a view to test the amount of friction of the air in entering the cylinder at the high velocity, and a simple method was adopted of ascertaining this. A tuyere was made as large as the inlet port, and the engine was driven to nearly or quite 700 feet per minute, when the gauge showed a pressure of $\frac{1}{4}$ of a lb. per square inch; and as the friction would be the same through the same sized openings at other pressures, it follows that the loss by friction on a pressure of blast of $3\frac{1}{2}$ lb. per inch, would be $\frac{1}{16}$ th or $6\frac{1}{2}$ per cent loss; as the port in this case was $\frac{1}{16}$ th of the area, and the port proposed is $\frac{1}{16}$ th, it is assumed that the loss would not exceed 5 per cent. from this cause, or indeed from any other cause, as the friction from propelling the air through a given sized tuyere, at a given pressure, must be the same in both cases.

Following up the comparison of first cost, we find (that exclusive of boilers, which are assumed the same in both cases, but taking into account the cost of the engine house,) there would be a saving by the proposed plan of between 65 and 70 per cent.; the cost of a pair of the best engines in Staffordshire, blowing three furnaces, being 3650*l*., while on the proposed plan they would cost 1100*l* if high pressure only, or if high pressure and condensing 1350*l*., including in each case the engine-house but not the boilers.

Many will prefer high pressure only, on account of its simplicity, but as it appears evident that a given quantity of steam can be condensed in the same time, in the same condenser, whether admitted in a few large jets or in a great number of small jets, there is no reason whatever why a condensing apparatus may not be attached to the short-stroke engine at high velocities; the only condition being that it must be equivalent to the power of the engine without relation to the size of the cylinder. The air-pump in this case must be double acting with slide valves, or it may be rotary and placed round the crank-shaft, and there appears to be no advantage in a fly-wheel for such an arrangement of blowing engines.

The speed of the engine should be regulated by a hydrostatic governor, communicating with the blast main, and attached to the throttle valve, exactly similar to those used in gas works for regulating the engine driving the exhausters; this would regulate the engine with greater delicacy, and maintain a more uniform blast than can be done with the present engines; and the rapid succession of the strokes of the two small blowing cylinders acting alternately, would render the present large reservoir quite unnecessary.

Supposing the advantages claimed for this description of engine to be realised, which the writer has no reason to doubt, it may be applied to assist the present blowing engines where they are overpowered, which is in many instances the case, as there is no ready means of increasing their power as the works develop themselves, and greater calls are made on the engine; but in the case of the proposed engines, if at any time an increase were desired another blowing cylinder might be added to the shaft, at a comparatively small cost.

Referring again to what first drew the attention of the writer to this subject, the employment of small cylinders worked by the pressure of air, where it was inconvenient or impracticable to employ shafting; it has been found that a 12-inch air cylinder with 8 lb. pressure attached to a large foundry crane, under which fifteen 30-inch pipes are cast vertically every ten hours, does the work of

double the number of men that could by any possibility work at the crane.

This suggests the possibility of a very considerable advantage to railway companies, by the use of the proposed engines, as the blowing cylinders for compressing the air might be attached to the end of the piston-rod of any of the small-sized engines now laid up at several stations, and the air conveyed to the various cranes, to which cylinders might be attached for about 25l. per crane, without disturbing the present arrangement for the use of manual power in cases of emergency. The saving of manual labour by such an arrangement will be best estimated by the managers of goods departments, some of whom are amongst the members, and with reference to the mechanical application of the power, the writer hopes to have the pleasure of presenting the Institution with another paper at some future meeting.

At the conclusion of the reading of the paper, several questions were put to Mr. SLATE, and which he answered. He stated that he had used fans made according to Mr. Buckle's principles, and could speak to their excellence and superiority; they were the least expensive in construction, being made with light wood arms, and he had obtained from $4\frac{1}{2}$ to 5 oz. per square inch pressure with them. He had tried both the cylinder-blast and the fan-blast for melting iron, and indeed had them both now in use; but he was of opinion the cylinder-blast was decidedly the best for the purpose, as the fan-blast caused the lining of the cupola to burn away quicker, and also consumed a larger proportion of fuel. He had found they could not blow so continuously with the fan-blast, and required to stop more frequently for repairs of the lining than with the cylinder-blast. The pressure of the fan-blast was not sufficient to carry it through the burden, so that the passage of the air was more at the sides of the cupola, which caused the lining to be cut away, and hence he considered the cylinder-blast was the best for melting iron; and though it might not be so cheap at first cost, there was no doubt of its ultimate economy. In the thousands of tons which he had melted, he had been unable to detect any difference between the quality of iron made under the influence of the fan and that made by the cylinder-blast. The pressure with the cylinder-blast was about $3\frac{1}{2}$ lb. per inch at the cupola, and they had six 1-inch or $1\frac{1}{2}$ -inch tuyeres. In the case of the fan, they had two tuyeres about 6 inches in diameter. They used best Durham hard coke, because light coke was useless with the cylinder-blast, which would blow it away.

Mr. DAVIES said, he made an exhaustor that had been used extensively for blowing copper-melting furnaces, but he believed the fan was preferred, though it gave less pressure of blast.

Mr. ROBINSON thought the fan-blast was best for a cupola, and he could not see the reason why the cylinder-blast should not injure the sides of the cupola more than the fan-blast, because it had greater pressure, and must have more power to force its way through to the opposite side.

Mr. COWPER thought there would not be any greater destruction of the lining with the fan-blast, unless there were some other cause; the circumstance of blowing with six tuyeres in the one case, and only two in the other, might cause a difference. At the London Works the cupola was blown with a fan-blast, and had two 10-inch tuyeres at 3 oz. pressure, but they did not find the sides cut away; on the contrary, with some trifling repairs each morning before starting work, the lining of the cupola lasted for many weeks.

Mr. W. SMITH remarked, that he did not know any instance of the fan being applied to blast furnaces in that district, and it was for those more particularly that Mr. Slate's engine was proposed; the question raised by the paper, was whether in the case of blast furnaces it was better to employ a small cylinder at a high velocity, or a large cylinder at a slow speed. This small blowing engine was proposed to supersede the ponderous machines which were employed for the purpose at the blast furnaces; he considered it was an important suggestion, and he saw no reason why it should not accomplish the object intended.

Mr. COWPER was of opinion that the proposed quick motion would give a more regular blast, which was a matter of great importance as affecting the make of iron; but it was a question whether the great speed at which it was proposed to be worked would not injuriously affect the durability of the working parts of the engine.

Mr. MCCONNELL did not think there was reason to fear any serious objection from that cause, when it was borne in mind that the piston of a locomotive engine frequently worked at the velocity of 800 feet per minute, and the proposed engine would be stationary instead of locomotive.

THE TUBULAR BRIDGES.

The Britannia and Conway Tubular Bridges; with General Inquiries on Reams, and on the Properties of Materials used in Construction. By EDWIN CLARK, Resident Engineer. Published with the sanction and under the supervision of ROBERT SEYMOUR. London: Weale. 1880.

THE Tubular Bridges may now be supposed familiar to all; and in taking up a book on the subject, however important, we have some fear lest what we say, as being supposed to be on an old and known subject, should not be listened to. The event is not near enough to have the prestige of novelty: it is not yet far enough for curiosity again to rise as to the actors by whom brought about, and the circumstances attending it. Our reading of Mr. Edwin Clark's book, however, has heightened our feelings; and though in the pages of this *Journal* we have over and over again written of the Britannia Bridge, we are not without hopes that our readers will go with us in reviewing, on this the first complete opportunity, the history of one of the greatest works of modern times, of a great monument of our days, which, notwithstanding the sneers of those who can properly appreciate neither antiquity nor the present, are more fruitful in great moral events, and in vast physical exertions than the world has yet seen. Many of us stand but as flies upon the axle; but as the wheel of Time's car runs swiftly on its way, the wonders of bygone ages are quickly surpassed, and events, each in itself the worthy subject of a history, are crowded before us. When Alexander wept that he had no more worlds to conquer, when Napoleon, greater still, thirsted for victory in Russia, or even when he was tottering to his fall, the world was not so much moved as now; for though the fate of single nations might waver under the beam, the lot of mankind and the welfare of beings yet to be born was hardly at stake. The revolution which has shaken Europe, the sudden chance which has unlocked the golden stores of California and opened a new world in the Pacific, the spreading influence of the older English in China and Hindostan, and the southward march of the two great English races to grasp the lordship of America, are events which would have dazzled the older historians, and awakened the inspiration of a Thucydides, Livy, Gibbon, or Niebuhr; but these events have not come alone. Kings and nations, we know of old, can rise and fall; but time and space, eternal in their laws, are now made sensible to us under very different conditions. Every day we are made more and more aware of the mighty influence of those applications of steam and electricity, by which the ends of the earth are being brought together, and the most distant lands drawn within our reach. In such mighty operations it is that the man of science is made sensible how much, by well-directed exertion, he may influence the destiny of mankind; and even the humble mechanic is called on to take part in these great actions. This is one—not the least important—of the new aspects under which the world appears. Plato might strive to influence statesmen; Aristotle gain the ear of Alexander; Seneca train up a Cæsar and find him a Nero; Bacon vindicate the claims of philosophers to political influence; but such men could never hope successfully to overcome the stubbornness of their instruments, the chances of education, the vicissitudes of party intrigues, or the disasters of barbarian warfare. It is by giving less predominance to speculative science, and a more practical turn to the labours of students, old and young, that a change has been produced; and the modern historian must attribute as great an influence to a Watt, Trevithick, or Stephenson, as the older historians to Socrates, Aristotle, and Bacon. It is not that morals have lost by this change: it is that they have gained by the application of intellect to practical results, instead of the elaboration of a Republic, a Utopia, or an Oceania; and the contrast of the two systems does not rest on a bright image of the present, and a dim remembrance of the past, for we have them face to face by summoning a Kant, Fichte, and Hegel.

If, however, the change is now most apparent, it has not been suddenly brought about, for the foundation is what Bacon laid and Newton worked upon; and the superstructure shows most now, for the foundations are deep. In proportion as this practical system is carried forward, so must the share of the engineer be greater, and the influence of the practical man be increased; and the mechanic will hereafter seek that participation in great deeds in the workshop, for which his fathers shed their blood on the battle-field. In the presence of the moral results that are obtained, the ambition of the engineer will take a nobler direction; and works will be carried out from motives of humanity, the magnificence of which would never attract capital, nor allow of a profit.

The wants of the present day require vast appliances, and the consideration of the instruments which are at our disposal is not among the least pleasing meditations, while casting a hopeful glance at the future. Viewed under the inspiration of all these considerations, the Britannia Bridge seems invested with an influence, the possible results of which can hardly be appreciated. It is not only a great work in itself, but it is an extension of mechanical power such as enables us to work out still grander designs. Everything which is a means to a great end calls for our observation; but those which are the most powerful in their results, whether a telegraph wire or the beam-bridge, justly claim our most serious attention.

The engineer, in contemplating the structures which have given rise to these remarks, neither irrelevant, we hope, nor unworthy of them, will chiefly have regard to two conditions—first, as to the means of completely imitating them, and next, as to the possibility of the application of the same construction on a larger scale. As a record of the Britannia or Conway Bridge, we should care little for any work; but it is in their results, in their influence, that our interest lies. Mr. Edwin Clark, the author, has well understood the conditions required, and he has therefore laid down a text-book, which will not merely be read and referred to, but which will be worked out by the engineer engaged in some like undertaking, perhaps among the steppes of Russia, the jungles of Hindostan, or the prairies of the far west. To enable this to be done effectually, it was needful not only to describe the works, and the way in which they were built up, but to investigate the principles in conforming to which their stability depends. In the case of an arch or suspension bridge, or a lighthouse, this has been already done; but the hollow beam being new, it will be seen how great is the task imposed upon the author; and hence the work, being carefully and ably performed, as here, how valuable in its teachings.

Such then is the book before us, and familiar as its subject may at first sight appear, it is most difficult for us, within our limits, properly to bring it under the notice of our readers, for we should be obliged to enter into many details at the same length as the author, or to reproduce his statements. We are therefore obliged to adopt a less systematic course, and taking it as our text, offer such observations as occur, leaving the analysis of the book to our readers, who will not wait for our bidding to buy it, and who are as it were constrained to read what is the standard work of engineering literature in the present day.

First, we must allude to the feeling of gratification which all members of the profession must entertain towards Robert Stephenson, for promoting the publication of this work. It is a graceful recognition of the duty incumbent on all to contribute to the common stock of knowledge, from which each gleams, and none more than those whose own achievements are greatest; and we feel a personal satisfaction in having constantly urged on the profession the discharge of this duty, because we know that we are answered by the sympathy of those whom we address. We may be forgiven for this personal allusion, because in a profession so newly risen to a great height, neither are the duties of its members well understood, nor the value of a technical periodical properly appreciated. We call the attention of our readers to ourselves, because it is as a means of serving their interests. The more readiness shown in giving information to the public, the greater the aggregate result and the benefit to each; for the influence of the press is not confined to general suggestions, being more especially owing to the diffusion of information to an extent which is little known, and can therefore hardly be conceived. In Mr. Clark's work, at p. 651, will be found a reference to our pages, and others are made by him and Mr. Stephenson to our contemporaries; while within the last few months alone, our pages have been acknowledged as a source of information to members of the profession in Rio Janeiro, in Canada, and in Hindostan. Who cares about giving information to others in India or America, yet it was by gleaming information as to a covered viaduct in America (p. 23), as to an accident in a dockyard at home (p. 30), that Robert Stephenson obtained the corollary evidence on which to justify his vast design. We do not feel disappointed with the success of our exertions—far from it, they are beyond what we could ever have expected; but we speak because we wish to stimulate the great body of engineers to the communication of information upon which too many are neglectful, either as thinking too much of their works, and selfishly keeping their knowledge to themselves, or thinking too little of what they see, and passing over what they think trifles.

Under these circumstances, Mr. Clark's book is invested with

the character of a record by its maker, of a great undertaking rather than the narration of an historian. Robert Stephenson has not only supervised the whole work, but he has written a section of it; it contains his letters and reports. But, above all, Mr. Clark was in this whole business his bosom friend and helpmate, knowing of all that was done; partner of every doubt, of every fear and every hope; present at the rise of each new suggestion, and taking part in carrying it to fruition. The book justifies, therefore, the character we have given it, of being one of the great standard works, and we hope many others are to come. In many professions the reward of excellence is so narrow that it is beyond the power of the members to incur any large pecuniary contribution; but the earnings of our great engineers have been so princely as to leave no excuse of this kind, and little time ought to pass before the gigantic undertakings of the day are as well commemorated as the Britannia Bridge, of which we are now speaking, the Menai Bridge by Mr. Provis, the Plymouth Breakwater by Sir John Rennie, and the Skerryvore Lighthouse by Mr. Alan Stevenson. One very memorable circumstance connected with the Britannia Bridge is, the union in its production of the resources of theoretical research and of practical requirements, and the harmony and zeal with which, with a well-known exception, so many men of various acquirements co-operated in the achievement of this design. Whether it was from fellow-feeling for the engineer, burdened with a task almost impossible, or whether with the earnest desire of ensuring success for a grand conception, certain it is few men have had so many or so able helpmates. The report of the Admiralty engineers, Sir John Rennie and Mr. Rendel, made abortive a very admirable design; and it appears very questionable, whether in the conditions they imposed, they did not seek to make the passage of the railway impossible, and to favour the Porth Dyliden plan. The tribunal of the Parliamentary Committee was not the most encouraging for the announcement of the new plan; and incredulity was as strongly expressed at the suggestion of a beam 450 feet long, as when the father before a like audience spoke of locomotives running thirty miles an hour. If Robert Stephenson felt seriously the responsibility thrust upon him, he soon received the assurance of co-operation and support. Not only did he have the assistance of Mr. Fairbairn, Professor Eaton Hodgkinson, and Mr. Edwin Clark, but he found a liberal counsellor in the Astronomer Royal (pp. 453, 514), and practical supporters in Mr. Brunel, Mr. Tierney Clark, Mr. John Laird, and Mr. Miller. When it is remembered the feud was still raging as to the broad gauge and the narrow gauge, the atmospheric railway and the locomotive, in which the two great engineers were pitted against each other, and that throughout they have been rivals for fame, it is not the less remarkable, and we are sure not the least pleasing, to find Robert Stephenson and Brunel working freely and earnestly together, and it is an event equally honourable to both. Throughout we find frequent references to communications from Brunel (pp. 401, 437, 441, 488, 510, 643, 680), and a most interesting description of his original application of the principle to a circular beam, 300 feet long, for a bridge over the Wye (p. 103). All the experience he had acquired in getting up the Hungerford Bridge and the Clifton Bridge was readily communicated, as well as that of Mr. Tierney Clark, as to the Peash and other great suspension bridges.

Another memorable circumstance was the costly series of experiments, and the lengthened scientific investigation forming part of the preparations. Distinct experiments were carried on by Mr. Fairbairn, Mr. Eaton Hodgkinson, and Mr. Edwin Clark, and those of Sir Mark Brunel and his son were freely communicated. These experiments were followed by a careful and laborious mathematical investigation, conducted by Mr. Eaton Hodgkinson, checked by Mr. Edwin Clark, and laid for revision before the Astronomer Royal, who, in one instance (p. 513), pointed out an erroneous deduction. The experiments began with small tubes and other slight models, and extended to a costly model made one-sixth of the size of the Britannia tube, or no less than seventy-five feet long (p. 184). Of course, the material being only in cubic proportion to that of the great tube, was very small (1 to 216), but the model was so large as to give a near approximation to the condition of the gigantic structure. The experiments of Brunel on a beam of 66 feet long (p. 437) are likewise on a large scale; and what may be called the auxiliary experiments are likewise unapproachable under ordinary conditions. Such are those of Mr. Fairbairn on an iron steam-ship 200 feet long, with 1200 tons of machinery in the middle; and such are those on the tubes themselves while on the platforms. The bridges were likewise the subject of experiment, and the opportunity was thus given of observing a beam 1511 feet long.

and weighing 4306 tons. This is an apparatus which Archimedes might have sighed for, and which modern science will know how to turn to account.

The cost of the experiments to the Railway Company was 6530*l.* (p. 811), besides the time of Mr. Stephenson and Mr. Clark, and without reckoning any contribution from extraneous sources. We are therefore justified in considering that a sum of 10,000*l.* was devoted to the experiments on which the tubular bridge was founded, and the book before us written. The experiments consisted of two great series, those at Millwall and those at Manchester. In the Millwall experiments the original cost of the large model was 320*l.*, and the repairs to it in the several experiments 800*l.* 13*s.* 4*d.*, making a total of 920*l.* 13*s.* 4*d.* The Manchester experiments were continued from January to December, 1846, and cost nearly 4000*l.* Some of the tubes tried in experimenting were afterwards used up for chimneys and otherwise on the works at the Britannia.

We shall now turn to a personal question, which is rather of a painful nature; and that is the question between Mr. Stephenson and Mr. William Fairbairn, and with regard to which the profession have looked forward to this book with some anxiety. Hitherto it was difficult to arrive at any correct judgment, though it was easy to see temper had more to do with the matter than anything else. We think we can make out our way more easily now; and we trust in the end these dissensions may be healed, and that we shall no longer on a grave and important subject have to regret bickerings which do injury to the cause of science as much as to the party in the wrong.

From this book there is no opening for doubt that Mr. Stephenson it was who first conceived the idea of throwing a hollow beam or covered bridge over the Menai; and therefore any claim narrows itself to after co-operation as to the development of the idea. Mr. Fairbairn was early called upon to assist, upon the very good ground that he had paid great attention to the strength of materials. No dispute exists, we believe, as to the extent of Mr. Fairbairn's co-operation—at any rate it is fully enough acknowledged in this book—it is only as to the nature of it. Mr. Fairbairn has set up the claim of being joint-engineer in the production of the bridges; but even on the technical grounds he has put forward, we cannot see there is any justice in this, or the assumption that his name should therefore be joined with Stephenson's on the bridges. We say, we do not admit even the technical grounds of the engagement with Stephenson or the Railway Company; but we do not allow that the question is to be argued on such grounds. Mr. Fairbairn has gone into a court of equity, he has opened the whole matter, and judgment is to be given upon the merits. The question then takes this shape—has Mr. Fairbairn an equal claim with Mr. Stephenson? We think not, because Mr. Stephenson was the originator, and because Mr. Fairbairn was introduced by Mr. Stephenson, and therefore subsidiary.

Looking at it in this light, we go the length of saying that had Mr. Stephenson made any bargain with Mr. Fairbairn for equal honours, he would not have been justified in doing so—he had no right to do so—and he would not have been acknowledged in doing so. The merit and responsibility of the suggestion was Mr. Stephenson's; and on the correctness of the principle it chiefly depended whether it could be carried out. The adaptation of the principle was a tentative process, and it matters little in comparison who carried it out. Mr. Stephenson provided the idea, he marshalled the staff for carrying it out, he procured the money for the experiments, and Mr. Fairbairn would have hardly done his duty creditably had he not achieved what he did. Granted there was a responsibility on Mr. Fairbairn—there was upon every assistant—and Mr. Fairbairn well fulfilled his duty, coming in at the beginning; and Mr. Stephenson's time being so fully taken up, the direction naturally fell upon Mr. Fairbairn, and thereby he had the opportunity of doing more than he would under ordinary circumstances; but that by no means raises him to the summit of the hierarchy, though it may advance his position in it. Whatever Mr. Fairbairn may put forward, the original position of Mr. Stephenson remains untouched; and it is hardly worth while to examine the technical grounds on which Mr. Fairbairn attempts to support his case. We are convinced his object is unattainable; and we are therefore the more concerned the controversy should drop, the ill-feeling be allayed, and the former cordiality be resumed.

On Mr. Stephenson requesting Mr. Fairbairn's co-operation, Mr. Fairbairn was officially appointed by the Railway Company one of its engineers, so as to give him the power to supervise contracts; but various circumstances occurred very materially to change Mr. Fairbairn's position. That he went zealously into the

work, Mr. Edwin Clark acknowledges; that he freely and liberally acknowledged Mr. Stephenson's origination of the undertaking, his letters show (p. 812); and that he was not knowingly a cause of the subsequent alienation, we fully believe. The taking out a patent for the application of the principle with Mr. Stephenson's concurrence was an effort of Mr. Fairbairn's zeal, but was an instrument of dissension, and the jealousy of Mr. Stephenson's supporters was aroused by representations in the Lancashire papers, that the undertaking was proceeding under Mr. Fairbairn's auspices. When the time came to contract for the work, and Mr. Fairbairn claimed, not unfairly, the lion's share (p. 807), it was a matter of course the Company removed him from the office of engineer, and substituted Mr. Edwin Clark (p. 808). After obtaining a large contract, Mr. Fairbairn resigned it, for a consideration, to Mr. Mare; and this circumstance, together with the heavy charge for the experiment, seems to have created an unfavourable feeling with the Railway Company. Mr. Fairbairn was thus in the end neither engineer nor contractor; and though he gave his co-operation to the last, it is easy to understand how an alienation of feeling arose, and a disappointment, which reacted in his requiring a greater consideration for his claims than either Mr. Stephenson or his friends were willing to acknowledge. Let it be hoped, nevertheless, that the handsome recognition of his services in this volume may be considered as a proof of kindly feeling to which he will reciprocate.

PICTURE GALLERIES.

CAN the characteristic forms and decorations of classic architecture be retained in modern buildings without deviation from their original constructive purposes? It is replied that the restriction of primitive forms to primitive uses can be complied with in no other edifices than those constructed on the type of ancient temples.

If this objection were valid it were idle to contend longer for architectural truth, for our advocacy would reduce us to this dilemma—we must either give up the use of classic forms altogether, or we must make all modern edifices in which they are employed similar to the Madeleine at Paris, mere copies of ancient structures. The objection, however, amounts to this, that the rules of Greek architecture are so strict as to be incapable of consistent application to any but a rectangular peripteral building. We concede at once that pointed architecture is infinitely more susceptible of variation than the rival style, from the simple reason that arch-construction remove from the former style the restrictions which in the latter limited the distance of inter-spaces to the length of a single block of stone. But in truth, classic architecture, even in its ancient simplicity and purity, admitted a diversity of construction which suffices to relieve us from the second horn of the dilemma above stated. The exquisite circular temple at Tivoli, and the atria of several houses at Pompeii, are among instances which might be cited of an application of the forms of Greek architecture, with perfect architectural truth, to buildings of which the plans entirely differ from those of the great Athenian temples.

The *Beslin* Gallery of Pictures must be regarded as one of the most successful instances of similar adaptation in modern times. This edifice presents a magnificent façade of eighteen fluted Corinthian columns, supporting an entablature and the flat roof of a portico which extends the whole front of the building. There is no pediment or other superstructure above the horizontal line of the entablature, but a higher roof rises at some distance behind it from the centre of the building, and is crowned at the corners by bold equestrian groups in bronze, which stand in admirable relief against the sky. The magnificent effect of the portico is further enhanced by the noble flight of steps by which it is approached; and the columns appear the more prominent from the wall behind them being richly decorated by deeply-coloured frescoes.

The light is obtained from the roof and side windows. The latter are not decorated by the ridiculous mimicry of pediments, which is nearly universal in England. There is not a sham-pediment nor a sham-column in the whole *Beslin* Gallery.

The arrangement of the interior is admirably adapted for the exhibition of its treasures. The Picture Gallery consists of a centre range of compartments, with suites on either side at right angles to it. The whole of this gallery is under one roof, and forms in fact one apartment, but it is divided by screens, extending from the wall between each two windows, to about three-fourths the

height and width of the gallery. The pictures are arranged systematically, according to the several schools of painting; the collection of sculptures is contained in three noble apartments below the picture gallery.

The Glyptothek, or Sculpture Gallery of Munich, exhibits the adaptation of classic architecture, with nearly the same constructive propriety as the edifice above described. The characteristic feature of the Glyptothek is its pediment, which however is not fixed against a blank wall for unmeaning ornament, but is the real gable-end of a real roof. The tympanum is richly adorned with sculpture, and the entablature is supported by a double range of Ionic undated columns. On either side of the central pile are wings, having distinct and lower roofs. The great defect of the building is the surface of blank wall which is displayed by these wings, and which is only imperfectly relieved by pilasters and niches, surmounted, unhappily, by miniature pediments. Exactly opposite the Glyptothek is the School of Art and Industry, resembling it in the main features of a central portico and side wings, but far superior in its general effect. For in the latter building the pediment is loftier, and supported by magnificent fluted Corinthian columns. The wings are without the objectionable pediments, and the blankness of the walls is far more perfectly relieved than in the Glyptothek, by regular ranges of bold pilasters.

The Pinacothek, or Picture Gallery of Munich, is chiefly admirable for its interior arrangement and decorations. The front somewhat resembles in form, though it greatly exceeds in size, the river front of Trinity College, Cambridge; and both buildings have the common defect, that the space occupied by windows bears too large a proportion to the rest of the exterior surface. Here, as at Berlin, the pictures are systematically arranged according to their schools, but the classification is even more perfectly effected. The gallery consists of a continued range of nine halls, communicating by central doorways, through which a vista extends the entire length of the building. There is a parallel range of cabinets, or smaller apartments, each of which communicates directly with its adjacent hall, and contains the smaller or cabinet pictures of the same school and epoch as the larger works in the hall adjoining. The spectator who visits each hall and its appendant cabinets in due succession, progresses gradually from the earliest German school of Albert Durer and Van Eyck to the perfect development of Italian art, in the works of Carlo Dolce, Titian, and Correggio.

The Dresden Gallery as far exceeds in extent the galleries of Munich and Berlin as do those of London. And yet this most wonderful collection is housed in a building nearly as ugly as our own National Gallery. The arrangement of it for the purpose of exhibiting its treasures is however immeasurably superior. The gallery is contained in a square building, with an inner court; and is there of the form of a hollow square, which is divided into two others by a quadrilateral partition, nearly midway between the inter walls and the sides of the inner court; so that there are two quadrilateral ranges of apartments, one within the other.

Here are none of the gorgeous architectural decorations of Berlin, or the elaborately tessellated floors and richly gilded ceilings of Munich; but the plainness of the casement is amply compensated for by the richness of its jewels. A lover of art unaccustomed to that profusion of pictorial wealth which Italy alone possesses, views with amazement the enormous number of masterpieces which the capital of the little kingdom of Saxony possesses. The *Madonna and Child* of Raphael attract homage, which is not the mere hyperbolic of dilettanti-ism; there is a secret magic in the picture, which rivets the attention of the humble artisan and simple countrywoman. It is before that picture that the greatest throng is seen, when on Sundays the gallery is most accessible to the poor and illiterate; for in Dresden picture-seeing is considered a more suitable occupation for the populace on Sunday than dram-drinking.

Whole rooms full of master-pieces of Titian, Correggio, Rembrandt, and Rubens; perfect specimens of every variety of art, from the minute Flemish pictures of low life to the loftiest of Italian representations of history; from the sweet simplicity of Murillo's peasants to the proud dignity of Rembrandt and the luxury of Titian; the tranquil sunset of Claude and the wild storm scene of Salvator Rosa—all are there. The eye becomes at last sated, not wearied, with the beautiful; and yet even when his powers of attention have been exhausted, the stranger feels reluctant to turn away, for the mere consciousness of being among the noblest efforts of genius and art is a fascination to him.

It is with a feeling of humiliation and painful regret that we turn to the degradation of art in the largest capital in the world. What insufferable sordidness and perversion of taste are concentrated—quintessenced—in our Trafalgar Square! Not to speak of

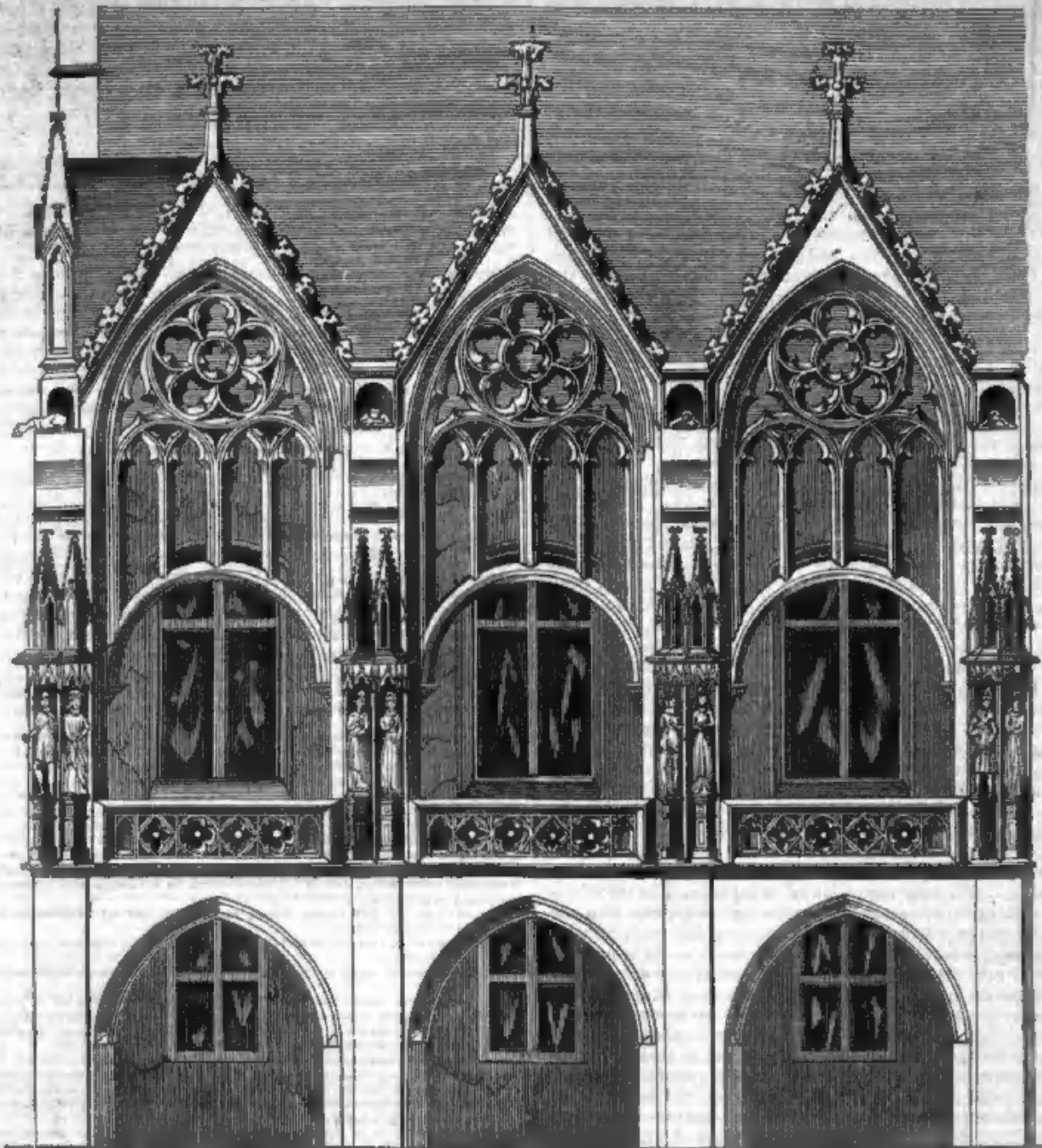
the "hideous absurdities" dotted about it—the contemptible fountain and monstrous column! what but inevitable necessity or a long education in the rules of bad taste could reconcile us to the pile in which our scanty store of pictures is huddled? One half the building, wretched as it is, is not our own, but given away to a company whose traffic in an annual raree-show debars the nation from enlarging its collection by purchase or private munificence, and compels the crowding what pictures we have, without system or method, half out of view, into ill-ventilated, ill-planned rooms, or dark underground cellars.

It has been objected to the extension of the national collection, that a general taste for art would render the people effeminate and ultimately licentious; and we are referred to those ages and nations which have been most devoted to art, as examples of extreme profligacy. Let us concede that licentiousness and professed love of art held sway in the court of Louis XIV.; the art was as licentious as the morals of the court, the offspring not the parent of luxury. An idle, self-indulgent people like the Italians, will encourage painting among other sources of enjoyment; a pleasure-taking Bavarian monarch recreates himself in adorning his capital. What then? does it follow that because vice encourages art, art encourages vice? By no means; for in all instances which can be referred to on the subject, the element of self-indulgence already exists precedent to the encouragement of art. But to show that such encouragement has itself a vicious tendency, it would be necessary to cite instances of its producing corruption where none previously existed. Such instances are wanting. On the contrary, we see the honest, true-hearted Germans devoting themselves to music without losing their simplicity of manners (excepting in those capitals where independent causes of contamination exist); the hard-working Flemings retaining their industry amidst the unparalleled fertility of their school of painting.

The English are eminently a hard-working people. The peasant works hard a-field, the country gentleman at sessions; the mechanic toils at the loom, the duke at public business, and our very sports are severer labour than the daily toil of other nations. We rise up early, and late take rest, and eat the bread of carefulness. Is there the slightest chance that the occasional inspection of a picture gallery will destroy this element of the national character, and render the people inert? On the contrary, the necessity for industry is goading them the other way.

The fact is, that all work and no play is making John Bull rather a dull boy. He has not holidays enough, and he does not know how to enjoy those he has. He requires more indulgence than a lecture on carbon at the mechanics' institute, or the evening class for improving his mind after work-hours. If extra indulgence be not granted him of a rational kind, he will find it for himself of an irrational kind in the follies of the casino and horse race.

The British Museum is a growing institution—why should not the National Gallery grow also? The British collection of marbles is not so very far inferior to those of other nations, because it receives constant accessions. Even within the last year or two, its additions have been extensive and valuable, and the expense of them is reimbursed by the nation ungrudgingly. But the collection of ancient masters of painting makes no progress, simply because there is not room provided for more pictures. To allege that no more *chefs d'œuvre* are obtainable because they are all secured for other collections, is to ignore the fact that within a comparatively recent period a large and invaluable collection was disgracefully lost to this country and deposited in the Louvre. Such opportunities, once neglected, seldom recur; but others of a minor nature still occasionally offer themselves, and a vigilant administration of the National Gallery, together with increase of room, might still render a respectable collection possible. On the principle that any building is better than none at all, an incessant din ought to be kept up about the ears of government, until the half of the present Gallery of which the public has been so long defrauded, has been restored, or the whole enlarged by an upper story. Such a superstructure, if designed with taste, would remove several elements of the hideousness of the present building. The disproportion of the length to the height would be mitigated, and we might even dare to hope that the sham dome would disappear. The pile might be made to look better—we know that there is no fear of its being made worse; and even if all its worst features were retained—why the English are so disciplined in the school of deformity, that they would submit to the infliction with exemplary resignation.



TOWN HALL, BRUNSWICK.

This portion here given forms part of the left wing of a considerable building, which is a good specimen of the fine halls of the middle ages, of which we have several examples in our own country. In the north of Europe the Rathhaus, or Hotel de Ville, is always among the chief structures in any town of moderate pretensions.

The building now under consideration dates from the fourteenth century, and exhibits the peculiarities of an open-worked screen of the Decorated style, carried along the whole of the principal front of the building. This is of a particularly pleasing character, and shows considerable ingenuity in design, and freedom in execution. The tracery in the head of each compartment is carried on a semi-circular arch, and the heads of the windows are likewise circular. The details are executed in much the same manner as those of the corresponding period in England; and the statues in the niches are those of the reigning dukes and duchesses of Brunswick. A similar arrangement is sometimes found in the cloisters of cathedrals and conventual buildings.

The centre piece of the tracery is a pleasing combination. It is a cinquefoil clustered round a circle, and contained within a circle. The lower part is divided into semicircular-headed arches, and these again are divided by trefoil heads. The whole is treated so as to produce an effect of great richness.

SANITARY MEASURES.

In another column will be found the report of the Sewers Commission on the amended plan of drainage they now propose for the metropolis. This speaks for itself, and we need not describe it; but we are glad to find that the Commissioners have attended to the voice of the press, and that one important object is secured—the non-pollution of the Thames in its course through the metropolis. The nuisance of the sewers has become so great that it can no longer be borne, had Sir John Burgoyne or any other of the

Commissioners persisted in upholding it. The Thames is now so much used in summer-time for short, or, as it may be called, omnibus traffic, as to make it highly needful to keep it free from poisonous influences. All through the season Hungerford-pier, one of the greatest places of traffic on the river, has been made an annoyance, as a large sewer discharges its noxious contents over the mud-flats reaching to the pier; and as the steamboats lie for a short time at the pier and are low down on the water, the ill effect to the passengers must be very great. Besides the usual abominations, this sewer seems to carry the drainage of a graveyard.

Whether the sewer water will be of much good in Woolwich or Erith marshes, we very much doubt. Sewer water, water charged with carbonate of lime, or any water, is a good fertiliser; but the expense of distribution, and the relative smallness of the area supplied will prevent any great results being obtained from the reservoirs in the marshes as compared with the quantity of fertilising matter collected from the metropolis.

In our late visit to Edinburgh, we made particular inquiries as to the working of the supply of sewage water there, which has been so much spoken of among agriculturists and professional men. We were informed that the sewage water is not so valuable for meadows as for market gardens; and we apprehend the same results will be found in Woolwich and Plumstead marshes, where the quantity of market-garden ground is very small. The value of grass land near Edinburgh is raised by the distribution of the sewage water; but the grass is found to be very rank. In another point of view, the application of sewage water is found highly objectionable, for whereas the aggregate agricultural benefit is small, the dispersion of the sewage water constitutes a fearful nuisance. When the wind at Edinburgh blows from the east over the meadows, it brings the most noxious odours; and this must be the case to the inhabitants of Greenwich, Woolwich, Deptford, and our eastern suburbs, if sewage water is used in the marshes. Thus all the usual evils of an easterly wind are aggravated.

Not only is the sewage water an annoyance to the people of Edinburgh, but it is said to be a cause of disease to those living in the neighbourhood of the meadows, so that many are in favour of introducing the Health of Towns Bill, in order to have power of grappling with the nuisance.

While we are pained with the prospect of the purification of the Thames, we cannot help feeling that much remains to be done in a sanitary and economical point of view. The entering of the waterclosets into the sewers has converted the sewers into a much greater nuisance than they used to be thirty or forty years ago, when no entries from waterclosets were allowed to be made. The introduction of fecal matter into the sewers brings noxious gases into the houses, and the water which is spent for washing the waterclosets acts to decompose the fecal matter. The waste of water is not the only economical loss, for there is a waste in London of a quantity of manure which would be equivalent to the growth of at least three million quarters of corn. While this fecal matter is sent into the sewers, neither large nor small sewers will work satisfactorily.

How this is to be remedied we are not prepared to state; but we think the attention of architects and engineers should be turned to the subject, with the view of determining on the best means. Several parties have proposed dry closets here; but we are given to understand that mainly through the exertions of M. Gauthier de Claubry, a member of the Council of Health at Paris, a system of dry closets, with the application of deodorising substances, is extensively and satisfactorily applied at Paris; and that under the direction of joint-stock companies, very valuable manures are prepared for agricultural purposes, yielding a large profit. This system of *fosses mobiles* will be found briefly explained in Weale's Dictionary of Terms.

Sewage water can only be applied to a restricted area, as the Edinburgh meadows or Woolwich marshes, and it will not pay for transmission to a distance; but solid manures can be sent even to the Indies, and admit of distribution over a wide extent of country. A ton of solid manure is of some value, and will pay for transit; but a ton of liquid manure is worth little more than a ton of water. The economical end to be obtained is, therefore, to get the manure in a solid form; and on every ground, if practicable, it is desirable that it should be collected at once, and not be washed with water, and then separated at an expense. It has been supposed that deodorising compounds lessen the fertilising properties of manures, though it is asserted by M. Gauthier that the system adopted at Paris and Lyon is found by experience not to be prejudicial. However it may be, the operation of water on night soil is decidedly objectionable.

At Paris the night soil is not being washed into the sewers, and in preference, they are emptying the cesspools by the pumping apparatus; but even then, instead of doing as our Commissioners of Sewers do, turning the night soil down the nearest drain, it is carefully conveyed to the works of the manure companies.

It appears, therefore, most desirable that the attention of all parties should be directed to the sewage system, with a view of accomplishing satisfactorily all the objects desired.

METROPOLITAN COMMISSION OF SEWERS.

At the last monthly general Court of Commissioners on the 9th ult., at the central office, Greek-street, Soho, the first portion of the general plan for the drainage of the metropolis was brought forward.

Mr. Woolrych, the secretary, explained an important error that appeared in the public reports of the proceedings at the Metropolitan Court of Sewers, held on the 28th of February, an error which has a material bearing upon the observations made upon the general conduct of the business of the commission. The item in question is thus described:—"Payments for books, surveys, management, &c., 85,346l. 3s. 6d." The error alluded to consists in the use of the word *books* instead of *works*, the item being described in the accounts presented to the court as payments for works, surveys, management, &c.

The Drainage of the Metropolis.

The committee appointed by the General Court to take into consideration the general drainage of the metropolis, and report thereon, determined to divide their labours into three distinct portions, or rather three distinct reports; the first to consist of a plan for the drainage of the southern side of the Thames; the second to consist of a plan for the drainage of Westminster; and the third to be a plan for the general drainage of the metropolis north of the Thames. The committee determined to take the drainage of the southern portion first into consideration, as its requirements seemed to them to be more immediately pressing than those of any other district.

The following is the engineer's report on the Surrey Drainage:—

"In obedience to instructions which I had the honour to receive from you on the 8th ult., I now proceed to furnish a report and estimate for a complete system of drainage for the Surrey and Kent districts, including extensive alterations in the inclination of existing sewers.

"Notwithstanding the labour and ingenuity displayed in many of the plans for the drainage of the metropolis sent in last year—some of which, as you stated in your report of the 8th of March, dealt ably with the general drainage on the north side of the Thames—I have been, as you are well aware, in laying out the plan of drainage for the south side, able to derive little or no practical assistance from any of them, which is to be accounted for, doubtless, by the necessarily defective data on which they were based, owing to the imperfect nature of the information which it was then in the power of the commissioners to supply to their various authors; but I feel it my duty to acknowledge in the outset the very valuable assistance I have received from plans and suggestions prepared, after consulting the block plans and subterranean surveys, by a member of your honourable commission, who kindly placed them in my hands during the preparation of the plan I have now the honour to submit.

"In drawing up this report I have, under your instructions, adopted the following principles for my guidance:—

"1. To keep the River Thames free from sewage at all times of the tide from Woolwich-reach upwards.

"2. To abolish all open ditches and cesspools, as well as defective, shallow, or high level sewers.

"3. To maintain a continual and uninterrupted flow, with the aid of lifts where necessary, in all the sewers along their whole length, by which the evils arising from back-up sewage—viz., the generation of noxious gases and the unavoidable formation of deposit in the sewer during its stagnation—may be avoided.

"4. To construct the sewers at inclinations so proportioned to the volume of fluid to be carried off by each that the velocity of the current shall keep them clear of deposit without the need of regular periodical flushing, which experience has shown to be not only troublesome and expensive in its operation, but also very injurious to the sewers and drains in which it is practised.

"5. To form the main sewers at such a depth as not only to receive the drainage of the deepest existing sewers, but to answer the purpose of main drains capable of extension towards the extremities of the district.

"6. To provide a natural escape by the power of gravity alone for storm waters and land floods independent of the ordinary sewers, whose contents will on the south side of the Thames require artificially lifting, and to construct the new sewers of such sizes only as may be sufficient to take the general drainage of the district, including ordinary rain falls connecting them at about mean low water, with outlets for heavy floods.

"7. To follow existing public streets, roads, or paths, so as to avoid heavy compensation for injury to private property whenever this can be done, without causing injurious curves or undue prolongation of the sewers, and consequent loss of level.

"8. To extend the ramifications of the sewers after the main lines are completed into all the streets at such depths and with such inclinations as to give perfect self-cleaning street drainage, and the opportunity for efficient house drainage.

"The following is a general outline of the means proposed to effect the objects above-named:—

"I beg to recommend the top of Woolwich-reach as the point for delivering the sewage into the river, because I believe that the matter so delivered at and after high water, and in the centre, and at the bottom of the stream, will not rise to the surface, as is to be feared by the inhabitants of Woolwich. If, however, it should be deemed expedient, either for agricultural purposes or for any other reason, to convey the sewage below Woolwich to some point near Erith before its delivery into the Thames, it may be effected by means of iron pipes across the marshes and through Woolwich, to be supplied by an engine and standing pipe erected at or near the Woolwich-road, near Greenwich-gate.

"Commencing with the outlet at a point 8 miles below London-bridge, it is proposed to form a double reservoir capable of holding at least 24 hours' drainage, covered over, and elevated to such a height as to discharge the whole of its contents at high water, delivering them by means of pipes near the middle and at the bottom of the river. The sewage will be lifted into the reservoir at this point (by means of an engine) from the main sewer, the invert of which is proposed to be at about mean low water, and 10 feet below the surface of the marshes.

"Hence the course of the main sewer will be across Greenwich marshes, along Woolwich Lower-road, Trafalgar-road, and Roan-street, to the Ravensbourne (where there is proposed to be a lift not exceeding 2½ feet); passes under the River Ravensbourne past the corner of the Trinity Almshouses, crossing Union-street and Bridge-row or Collier-street.

"This lift and shaft I propose to place completely under cover, and to connect with the chimney of the smoke-consuming furnace of the engine all the passages from which any gases could escape from the sewer, and I feel perfectly confident that with these precautions the possibility of any annoyance being caused to the neighbourhood may be obviated.

"I mentioned above that it was not proposed that the engines should have to raise all the storm waters or land floods; these will be provided for in extraordinary cases by the four existing outlets—viz., the Effra, the Earl, the Duffield, and St. John's sewers, and by means of reservoirs and a diversion of the upper part of the Effra to keep the low-lying and thickly-inhabited part of the district free from floods.

"From Collier-street a line which may be called the 'southern main line' diverges: the 'northern main line' passing along the Lower Deptford-road to the crossing of the Earl sewer, from which point it strikes into a north-westerly direction, and in a straight line towards St. James's church, Bermondsey, thence along Prospect-place to Dockhead, and thence to Gainsford-street and Tooly-street, where it unites with the great St. John's sewer, with which are connected the Battle-bridge and its various branches; the inclination of the new sewer for the whole distance being at an average rate of about 4½ feet per mile, somewhat less near the point of discharge, somewhat more of course as the volume of fluid diminishes at each successive ramification of the sewers.

"Returning to the diverging point at Deptford, the course of the 'southern main line' will be by Loving Edwards'-lane nearly in a straight line with Old Kent-road at Hatcham, along the Old Kent-road to Surrey Canal bridge, which is at the point of divergence of an intermediate main line to be afterwards described; the southern main line will proceed by Nest-street and Albany-road in a straight line across to St. Mark's-road, and by Camberwell New-road to St. Mark's Church, Kennington. Here it will pass under the Effra sewer and by a connection therewith will receive its ordinary run of drainage; the floods of the Effra being provided for by a relief line about 1200 yards long, passing along the Oval and Harleyford-street to Vauxhall-creek—the present open and most offensive portion of the Effra from Kennington-road to Vauxhall being filled-up and abolished.

"The level of the southern main line at St. Mark's Church would be about 10 or nearly 7 feet below the deepest sewer existing there at present, and will afford unexceptionable drainage for Stockwell and Clapham, Balham-hill, and the whole district lying between Brixton-road and Wandsworth-road.

"The course of the 'intermediate line,' diverging at the Surrey Canal-bridge, proceeds along the Old Kent-road to the Bricklayer's Arms, where it will divide: one arm passes along the New Kent-road to the Elephant and Castle, where it will receive the drainage of the Walworth and Kennington roads and a portion of London-road and St. George's-road.

"The other more northern arm of this intermediate sewer proceeds from the Bricklayer's Arms along part of the Dover-road and Trinity-street, crosses Blackman-street, continuing along Great Suffolk-street, across Southwark-bridge-road, along Suffolk-street, across the end of Gravel-lane, through Nelson-square, to Rowland Hill's chapel, at which point its level will be 0·40, being about 1 ft. 2 in. below the Battle-bridge sewer. This intermediate main line will be 2½ miles in length from the Surrey Canal bridge to Rowland Hill's Chapel—one-half of it through streets at present without deep sewers, and one-half along the line of an existing deep sewer, for which it will form a substitute, and the more southern arm passing up to and dividing at the Elephant and Castle, about one mile in length, along the lines of existing sewers. The inclination of the proposed new lines varying at the different parts of the sewer according to the branches received on the principle above mentioned.

"Consequent upon this intermediate main line being carried into the middle of the populous districts will be an alteration of the levels of above six miles of existing sewers in the following streets—viz., New Cut, Corowall-road, Waterloo-road, Borough-road, Newington-causway, Westminster-bridge-road, Lambeth-road, Westminster-road, parts of London-road, and St. George's-road. This will involve in addition much alteration in secondary drains and in house drainage; and I cannot quit this part of my subject without again suggesting to the commissioners the expediency of watching and testing the working of the present main drains as soon as the main sewers are sufficiently completed to do so, before they proceed to the extensive alterations in the existing sewers which the contemplated interference with them will involve.

"I beg now to lay before you my estimate of the cost of draining the district according to the system above described; but before doing this I would observe that in drawing up this report and these estimates, I have thought it desirable to put down the outside amount of lift, of depth of drains, &c., in order that if there be any error it may be on the right side. In this estimate I have neither included compensation for passing through or under private property, which, however, from the lines adopted in accordance with the principle you laid down, will be comparatively trifling, nor the cost of the detailed drainage, to estimate which will be a work of much time and lengthened inquiry. In any case this will involve a considerable outlay, but as it is dependent on the settlement and partial completion of the main drainage, it would have been premature to go into it here; neither have I taken into account the cost of extending the system of drainage into the suburban districts—a provision which it becomes daily more imperative to make.

Estimate of cost of system above described.

	Miles.	Fur.	Cost.
Main trunk drain from outlet in Greenwich marshes to the lift at the Ravensbourne	2	0 ..	£25,687
Reservoirs and outlet-pipes			30,398
Pumping engines and apparatus			27,400
From the lift at the Ravensbourne to a point near St. James's church, Bermondsey, north main line	3	5	46,930
Extension of north main line from St. James's church to the Great St. John's sewer	6	6	8,000
South main line from Collier-street, Deptford, to St. Mark's church, Kennington	4	0½	49,600
Flood line of Effra	0	5½	7,300
Intermediate main line from Surrey Canal bridge, with northern arm to Rowland Hill's chapel	2	2	15,000
Southern arm along New Kent-road	1	0	6,000
Alteration of existing sewers to connect with the intermediate main line, &c. ..	6	0	83,000
Effra flood line diversion by Fackham			7,000
	10	5	£241,297

"1, Creek-street, Bodo, 1st August, 1850.

"FRANK FORSTER.

"To the Hon. Metropolitan Commissioners of Sewers."

Mr. STEPHENSON, at the conclusion of reading the report and in moving its adoption by the Court, said—"I think it desirable to explain to the Court a few of the principles which actuated Mr. Forster in devising the plans which are now upon the table, and the reasons which guided him in laying them

down. Before commencing the consideration of these general principles, however, allow me to say, in reply to some complaints which have been made out of doors respecting the great delay which has taken place in proposing any general plan for the drainage of London, that the public must bear in mind that the commission has not been more than 10 months in existence, and that some of its members came into it quite fresh—unacquainted with a great number of the localities of London, and absolutely unacquainted with the complicated system of sewage existing, to the extent of nearly 600 miles. In addition to this, the underground surveys were in a very incomplete state, and no one could venture to say what general plan ought to be pursued at that time, as it was dangerous to commence with any one locality, for fear of interfering with the ultimate chance of success, London, however, divides itself naturally into two districts—north and south, and after the commission had examined generally the condition of these two districts, they found that Bermondsey, Lambeth, and Southwark were infinitely worse than the north side; to that portion, therefore, they have directed their attention, almost without cessation, during the last few months. I am glad to see these plans upon the table of the Court, having in view the establishment of a complete and perfect system of drainage for this district, which extends over nine square miles, three of which are from 6 to 7 feet below high-water mark. The whole eight or nine square miles vary from 2 to 6 feet under high-water mark. It will be apparent that to devise a system of drainage for this locality is a work of no inconsiderable difficulty. The locality may be said to be drained only for four hours out of the 12, and during those four hours only very imperfectly. The sewers now empty themselves into the Thames at various levels, and when the tide rises above the orifices of those sewers, of course the whole drainage of the district is stopped until the tide recedes again; thus the whole system of sewers in that locality may be said to be but an articulation of cesspools. The commission commenced the consideration of this subject with a sincere desire to accomplish the drainage by natural means, if possible; but it soon became apparent that these sewers, which were subjected for eight hours out of the twelve to a state of stagnation, acquired a settlement of solid matter which required even a more extensive system of flushing than that which we now possess. It has been proved by the last few years that even flushing, under each circumstance, is not efficient, and the tendencies in these sewers to form a concrete of hard substances is such as to render any current of water, however rapid and constant, quite ineffectual. Under these circumstances it became apparent that the commission must resort to artificial means of drainage, and pumping by steam appeared to be the most economical and the most efficient plan. Mr. Forster therefore proposed the establishment of a steam-engine at the Ravensbourne to lift the whole of the sewage of the district to a height of 20 feet, and by that means a current would be established so as to maintain throughout the whole day, without cessation, a constant flow, and the solid matter which now forms the subject of complaint would be carried off. The expense of pumping may at first appear to be very great. I thought so myself at the commencement; but when it was reported to me by the officers of the commission, that the cost of flushing and the cost of removing this solid matter now concreted at the bottom of the sewers would be very great, and that the cost of pumping-up the whole of the sewage matter would cost less money, I thought that the system of pumping, as applied to the south side of the Thames, appeared to be entirely without objection. I will not now go into the details of the works, as Mr. Forster has already explained them; and I shall move that Mr. Forster's report be adopted, and that the works therein recommended be carried out forthwith."

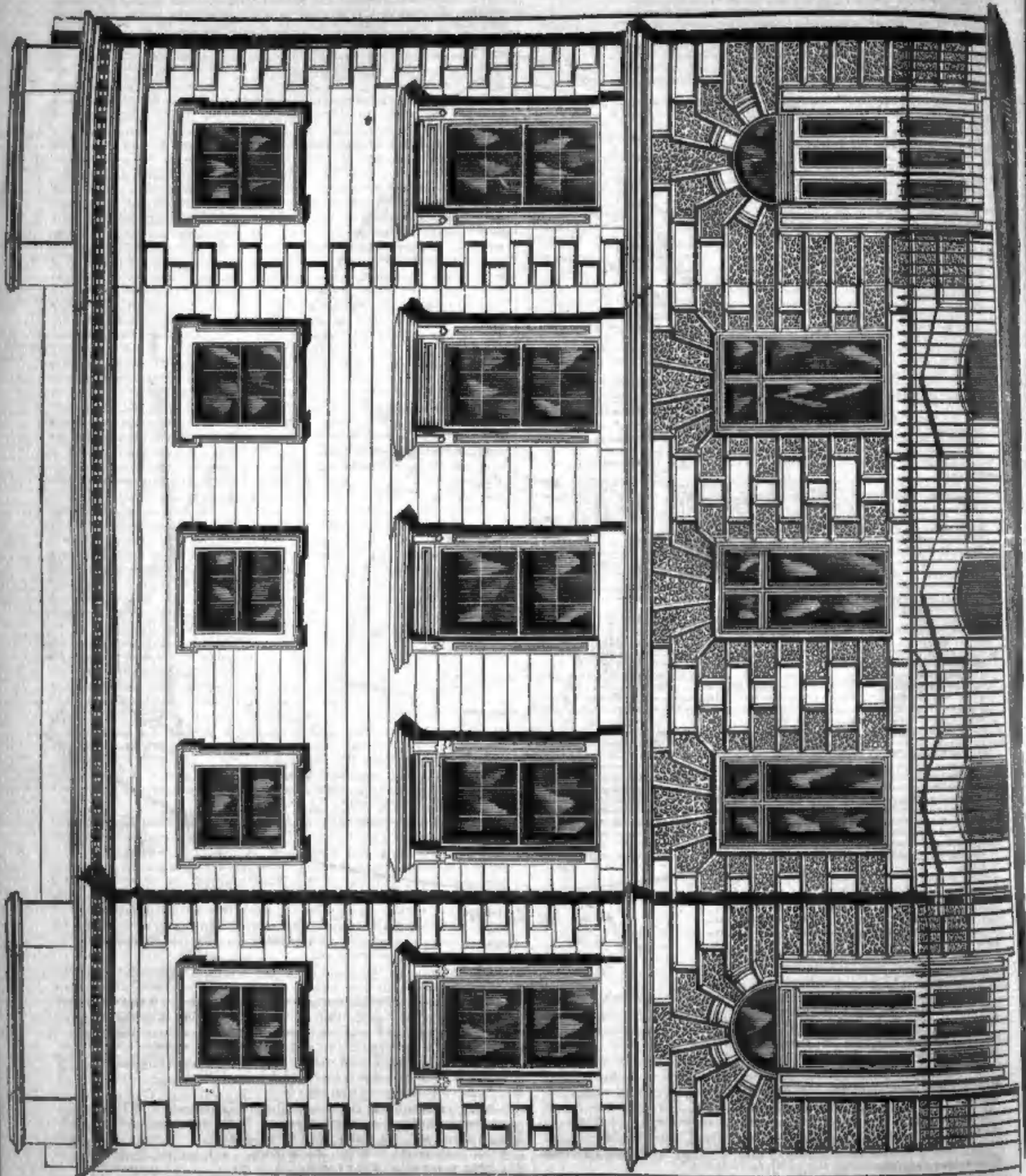
Sir JOHN BURGOYNE said: After the clear and full statement made by Mr. Stephenson, it is not necessary for me to go into any of the matters or details connected with this report, as it would only lead to confusion. It is, however, satisfactory to know that, after the consideration given to these general principles laid down in Mr. Forster's report, the commissioners are unanimous in adopting them; and that, with regard to details, there is no difference of opinion amongst us. I think that no dissatisfaction can be expressed by the public at the system which we propose to adopt; and I am glad to have an opportunity of expressing my own full concurrence in the report which has just been read.

The CHAIRMAN: The Court has at last succeeded in coming to a satisfactory solution of this very difficult question, and I was never more rejoiced than I am now to find that we have substantially brought it to a conclusion. I must remind the Court, however, of clause 17 in our act, which provides that no law shall be considered formally enacted by any court unless notice is given of it previously. I think, therefore, that we had better consider this day's proceedings merely as the required notice, and formally adopt this report at a future special court.

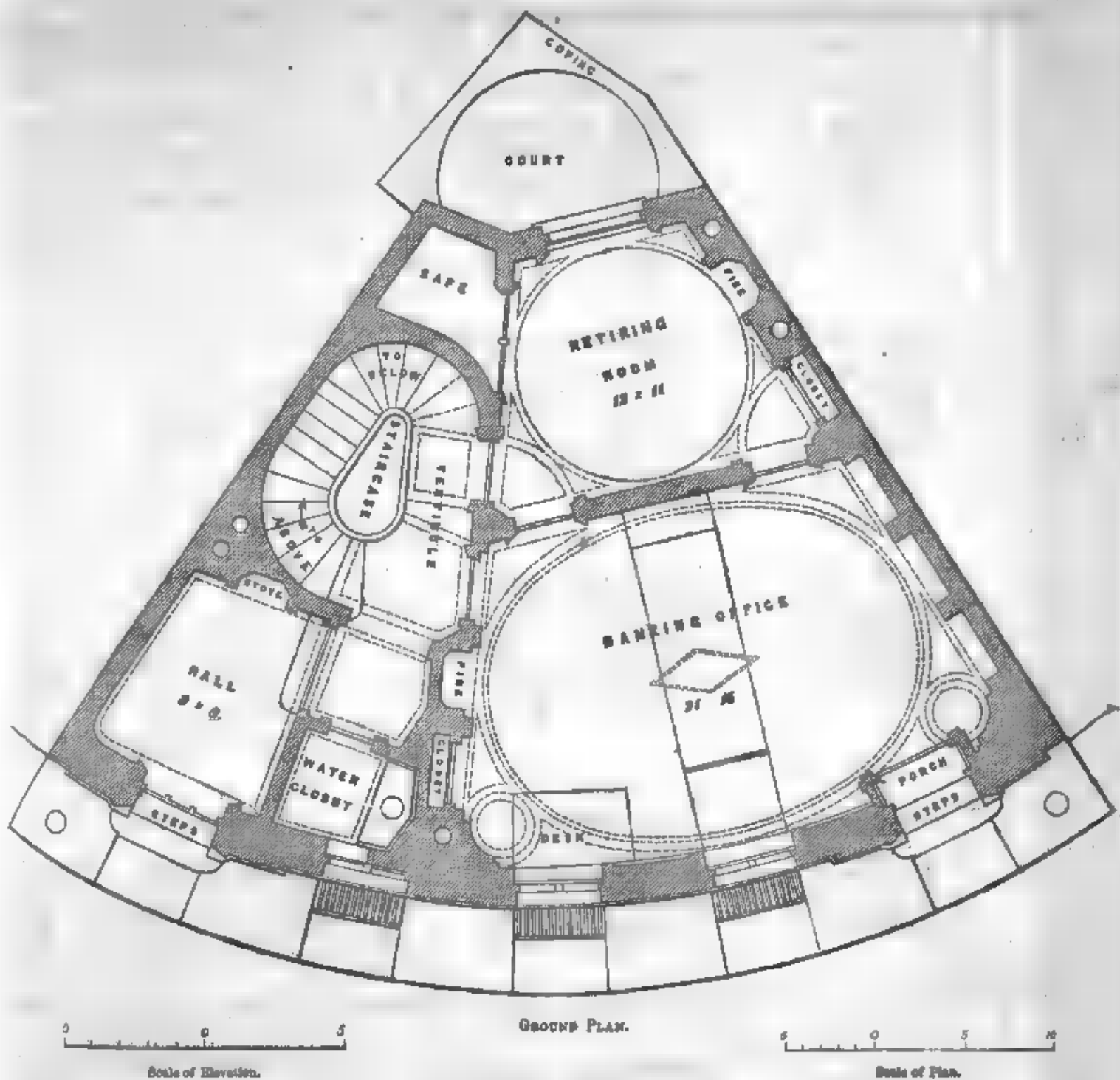
This was agreed to without remark.

Mr. HAWES said: In reference to the prompt execution of these works, we are now in treaty with several persons for the loan of sufficient money to carry them out. We shall require about 250,000*l.*, to be repaid in 30 years by 30 instalments, principal and interest. The expense so divided will amount to about 2*d.* in the pound.

Mr. HAWES, in answer to a question whether it was compulsory upon landlords to drain into these sewers when they were formed, said, the Act compelled every house within 100 feet of a sewer, to drain into it; and care would be taken to have a sewer within 100 feet of every house.



THE WHITBY BANK.
J. B. & WILLIAM ATKINSON, Architects.



The Whitby Bank is a very good example of a small branch bank in a district yielding stone. Such a building requires accommodation for the residence of the officers, and consequent safe custody of the property, as much as room for the business. Indeed, the banking office need not be very large, either for clerks or customers, in a small town. A branch bank must bring its staff within close compass: the manager is likewise clerk and custodian, and it is found economical to provide him with a residence. It is otherwise where the banking business is very large, for there the domestic part of the building is small, and there is more opportunity for architectural display, and a large hall becomes the distinctive feature.

The arrangement of the Whitby Bank is peculiar, and will be interesting to our readers, who will see what the architects have been able to do with an ungainly site. They have, it will be seen, given to their front a curved sweep, which has the effect of com-

municating to it a peculiar and marked character. In the interior the banking office is irregular on the ground plan, but the ceiling is elliptical; and the retiring room behind it, likewise peculiar in shape, is made symmetrical in the floor and the ceiling.

The building is of stone procured from the neighbourhood, and the dressings of the doors and windows are rusticated. The windows are for safety provided with Bunnett and Corpe's iron revolving shutters, and the safe is under the counter, and descends into a vault in the fire-proof basement. The safe is moved up and down by an hydraulic pump, and it contains all the cash drawers and the bank books. When down in the vault an iron door closes all. The total cost of the building and fittings was 18000.

The architects were Messrs. J. B. and William Atkinson, of York.

PHOTOGRAPHY.

Photography on Gelatine:—Means of obtaining very clear and very Transparent Negative Proofs, capable of being transferred a great many times on ordinary Photographic Paper. By M. A. POITEVIN.*

In order to prepare the layer of gelatine on which I make my negative proof, I dissolve in 100 grammes of water 6 grammes of gelatine of good quality (that which is met with in commerce, and which is used for preparing jellies for food succeeded best). This size should not contain salts soluble in water; it should also be as free as possible from fatty matters. To make the solution, I steep the gelatine in distilled water for 10 or 15 minutes; I slowly heat over a spirit lamp, and agitate continually until the solution is complete. If any acum forms, I carefully remove it by means of blotting paper, which I draw over the surface; I strain it through a very fine cloth, previously dampened, and I again skim the surface on which a few strins form, arising, doubtless, from fatty matters which escape the first skimming.

The gelatine being thus prepared, I take, with a graduated pipette, a determinate quantity, and I run it over a very even plate of glass placed horizontally; a layer of 1.50mm. is sufficient; this quantity is equivalent to nearly 20 centimetres of solution for a surface of half a plate having 13.5c. or 17.5c. A thicker layer would not be injurious, but a thinner one might present some inconveniences.

Before running the gelatine on the glass plate, a thin layer is applied to it by means of a cloth impregnated with a solution of gelatine, rather more dilute than the foregoing; afterwards, the glass plate is gently heated by means of a spirit lamp; then the solution of gelatine is run on, and flows uniformly over the plate. The under side of the glass plate is again heated, but with moderation, in order to give fluidity to the gelatine, and is allowed to cool.

The plate being thus prepared, I plunge it into a solution of acetate of silver, keeping the surface covered with gelatine underneath, and inclining it in the solution until the latter has completely moistened it; I then turn the glass plate and immerse it completely in the solution; then I pass a very soft pencil several times, and in different directions, all over the gelatinised surface, in order to dispel the bubbles of air which may adhere to it; and, before withdrawing it, I blow on the surface to ascertain whether the solution has moistened it all over. I then remove the plate, and holding it somewhat inclined, I pass the pencil already used over the whole surface, taking care to cover the edge of the previous stroke with that of the following one. I then dry the under side of the plate, and place it horizontally until the surface is dry, which requires five or six hours.

I ordinarily prepare over-night the plates which I intend to use on the following morning, and in the morning those which I mean to use in the evening. It is important that no free liquid should be left on the surface of the plate when it is required for use, for the preparation would be removed at the places where any remained. This preparation should be made out of the solar light. The plate covered with the solution of acetate of silver should be kept out of the light.

The solution of acetate of silver is prepared by making a saturated solution of acetate of silver, to which half its bulk of water is added. Admitting that 100 parts of water dissolve, at the ordinary temperature, 0.5 gr. of acetate of silver, to prepare 0.750 lit. of the solution which I use, I dissolve 2.5 gr. of acetate of soda in 15 grammes of water; I likewise dissolve 3.03 gr. of nitrate of silver in 10 grammes of water; I add the solution of nitrate of silver to the solution of acetate of soda, and I receive the acetate of silver which is precipitated on a filter; I wash the precipitate in a stream of water, then I pass through the filter several times 0.50 lit. of water; almost the whole of the acetate of silver should then be dissolved; I afterwards add 0.25 lit. of water to the half litre of saturated solution.

In this operation 3 grammes of acetate of silver are formed, the 0.75 lit. should contain only 2.50 gr., but I put in a little more of it to make up for any that may have been lost in the water of the solutions and of washing. The acetate of silver being very easily altered by the solar light, I make this solution as far as possible in a dimly-lighted place. I preserve it in a bottle covered with black paper, and filter it every time I use it.

I expose the plate prepared as above described to the vapour of iodine, in the same manner as a plate of silvered copper; only, for this exposure, account must be taken of the time, for we cannot

judge of the tint on the surface, only the time of exposure is shorter than for silvered plates. The iodised plate is placed in the frame of the camera obscura, and then I cover the side which is not gelatinised with a piece of card-board covered with black cloth. It is good to allow some time to elapse between the iodising and the exposure to the focus of the camera; the plate thereby gains in sensibility. I have sometimes used plates five or six hours after the iodising; they had lost nothing of their sensitiveness.

The sensitiveness of these plates is about one-fourth of that of plates prepared with iodine and bromine. For a landscape with much light and with an object-glass with a small diaphragm, the exposure in the camera may require from 80 to 100 seconds. Portraits, with strong lights and shades, may be taken in two minutes with the portrait object-glass. I have tried the effect of the vapour of bromine on these plates, and have found that it renders them more delicate. I have not made sufficient experiments to have certain data on this subject.

In order to make the image appear, I plunge the plate into a solution of gallic acid containing 0.1 gr. of gallic acid in 100 grammes of water; I leave the proof until the shadows appear sufficiently intense. This immersion may last an hour or an hour and a half. With a more concentrated solution of gallic acid, it would require a shorter time, but it would be more difficult to regulate its action. At the commencement of the immersion, a positive image is formed on the surface of the gelatine. This image becomes more and more dark; but, on looking through it, the parts corresponding to the shadows in nature remain very light.

To fix the proof, it is washed in ordinary water, and then left for about a quarter of an hour in a solution of 1 gramme of hyposulphite of soda in 100 grammes of water; it is again washed in ordinary water, and it is steeped for the same length of time in a solution of 1 gramme of bromide of potassium, in 100 grammes of water.

I wash the proof with ordinary water, allowing it to remain in it for fifteen or twenty minutes; then I wash with distilled water, and allow the layer of gelatine to dry in the open air. It is then a very clear negative proof, capable of giving positive proofs, with ordinary photographic paper, in the sun, in from 2 to 10 minutes, according to the vigour of the negative proof: it also comes very well in the shade.

It is well to renew, at each operation, the solutions of gallic acid, hyposulphite of soda and bromide of potassium.

In this operation, if the solution of gallic acid be replaced by a solution of sulphate of protoxide of iron, very beautiful positive proofs are obtained.

Photography on Paper:—Means of obtaining the Image in the Camera Obscura on Dry Paper. By M. BLANQUART-ÉVBAUD.

To render the execution of photography on paper simple, sure, and easy to those least experienced in chemical manipulations, should be the object of the efforts of those who wish to bring this art to its most useful application in industrial economy. The first condition for entering into this new order of things, is to rid the operation of the care which it requires at the time of the exposure. We open the way by giving here:—

1. The means of operating on dry paper, instead of damp paper, freeing the operator from the difficult preparations which he has to make at the places of exposure.

2. So simple a mode of preparing this photogenic paper, that it may be manufactured and sold to the amateur who does not desire the trouble of preparing it himself.

The papers prepared by the means hitherto described could not be brought to the dry state without afterwards taking, under the action of gallic acid, an uniform coloration which would efface the photogenic image, and cause it to completely disappear. Serum has the property of obviating this inconvenience; the following is the mode of preparation to be adopted:—

Collect, by filtering, the clear part of milk which has been turned, and beat up in this serum the white of one egg to each pint, then boil in order to remove all the solid matters, and filter again, after which dissolve without heat 5 per cent. by weight of iodide of potassium. The paper to be prepared must be very thick and steeped entirely in the liquid for two minutes, and afterwards dried by hanging it, by means of two pins, by two of its corners, to a line.

This preparation is made in the daylight without any particular precaution; the paper is fit for immediate use for six months after, and certainly after a much longer time. When it has to be used

* *Comptes Rendus*, No. 21, May 27, 1850.—*Chemist*, July 1850.

It is submitted to a second preparation, which is done by candle-light, and as short a time as possible before the exposure; it is, however, still capable of giving good results several days after, avoiding then, as much as possible, leaving it in a high temperature.

We proceed therefore in this preparation by covering a glass with aceto-nitrate of silver composed of 1 part of nitrate of silver, 2 parts of crystallizable acetic acid, and 10 parts of distilled water. On this substance is deposited one of the sides of the paper, which is allowed to imbibe until it has become perfectly transparent, which is ascertained by raising it between the operator's eye and the candle, after which it is dried between several folds of very white blotting-paper, and left so until it has to be placed in the frame, behind a sheet of very clean and dry paper, and between two glasses, as in the moist operation previously described.

The exposure to which we afterwards proceed next day, varies according to the light and the power of the object-glasses, from one to five minutes.

On returning to work, the part of the paper which has been presented to the light is deposited in a saturated layer of gallic acid, taking care to secure the other side from any trace of gallic acid which would stain it. The image is gradually formed, and finally acquires as powerful tones as can be desired; it is then washed in a great quantity of water, then parts into a solution composed of 1 part of bromide of potassium and 20 parts of water, in order to dissolve the unreduced salts of silver, then again washed to remove all traces of this bromide, whose action, by continuing, would destroy the image, and finally dried between folds of blotting-paper.

Preparation of the Dry Albuminous Paper.—The paper prepared by albumen has analogous properties to that in the preparation of which serum is used, but in an inferior degree; like it, it remains good for an almost indefinite period after preparation with the iodide, but, after having been submitted to the aceto-nitrate of silver, it can be scarcely kept beyond next day. The proofs given by the preparation we are about to describe are admirable; not so fine as those on glass, they have more charms, because the contrasts are less decided, and they possess more harmony and softness. We think that it is a real acquisition for those who seek the effects of art in the results of photography.

White of egg, to which have been added thirty drops of a saturated solution of iodide of potassium and two drops of a saturated solution of bromide of potassium to each white of egg, is beaten up to a snow. It is left to repose until the snow returns to albumen in the liquid state, and then filtered through silk or clear muslin, the albumen being collected in a large and quite flat vessel. The paper to be prepared is then deposited on the layer and left on it for a few minutes. When it is covered with albumen, it is raised by one of its corners, and allowed to drain and dry by suspending it by one or two corners from a line.

The preparation with the aceto-nitrate is, in every respect, the same as that described for the paper prepared with serum; care must be taken to dry it between two folds of blotting-paper only when the paper has acquired complete transparency. It is put into the frame for exposure in the same manner, the appearance of the image and the rest of the operation is the same; but the exposure requires a longer time, generally four or five minutes.

Preparation of the Positive Albumen Paper.—The positive paper prepared with albumen gives somewhat less brilliant proofs, but of a richer tone, and of a more agreeable finish and transparency; it is prepared in the following manner:—To the whites of eggs is added 25 per cent. (by weight) of water saturated with chloride of sodium. The white of eggs is beaten into a snow, and filtered as in the preceding preparation, only in this case the paper is left on the albumen for only half a minute. It is then hung up to dry, which is accomplished in six or eight minutes; it is afterwards deposited in a vessel containing 25 parts of nitrate of silver and 100 parts of distilled water. The paper is left in the bath at least six minutes, and afterwards dried flat.

CALEDONIAN CANAL.

The annual report of the Commissioners for making and maintaining the Caledonian Canal has just been printed. The report gives an outline of the operations of the Committee till the 1st of May last.

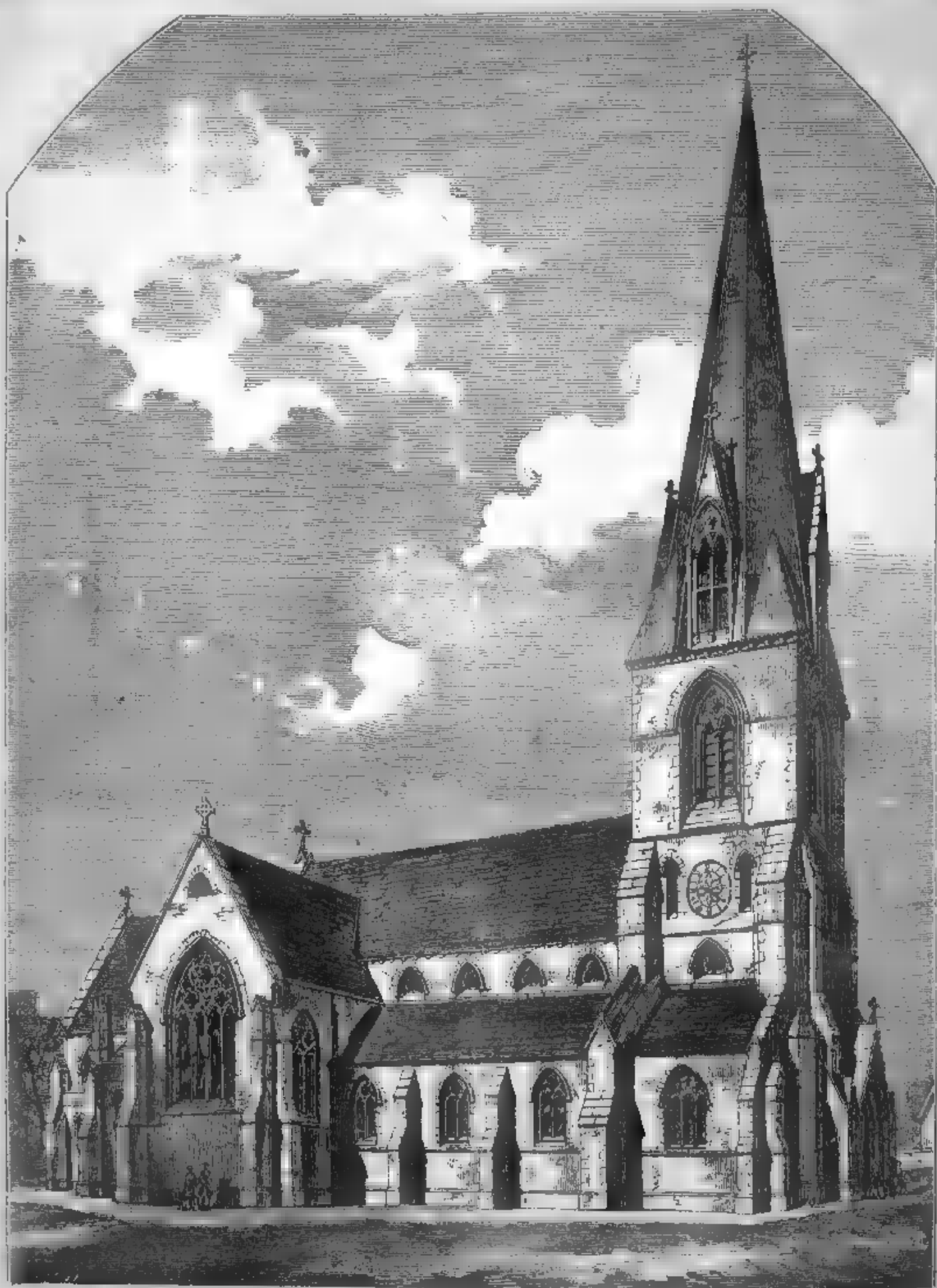
The repair of those portions of the canal works which suffered from the unprecedented floods of January 1849, has been entirely

completed in the past year, without interruption to the traffic. It has also been thought advisable to secure the works against the effects of a similar visitation, should such unhappily recur; and with this view, under the advice of Mr. Walker, the south-east bank of the canal above Doch-Garrock Lock has been strengthened, and raised about two feet and a-half above the highest level of the inundation. The gates of the lock itself are of such a height as to require no addition. An increase of two feet in height has been given to the canal bank of the reach above Aberchalder, and of three feet to the banks above and adjoining Leggan Locks; but in both these instances a corresponding addition to the height of the masonry and lock-gates is required, which has not yet been effected from the apprehension of temporarily obstructing the navigation.

Various additional accommodation and facilities for traffic have been supplied along the line of the canal, which leave little now to be desired for the convenience either of passengers or of trade. At Clachnaharry, the timber jetty at the Sea Lock has been extended so as to obviate the risk of vessels grounding on the sloping embankment: a similar jetty has been constructed at Corpach. At Muirtown, the road of approach to the steamboat wharf has been widened. The steamboat stations at each end of the canal have been properly lighted: the roadway along the Dochfour embankment has been completed and fenced. The only further accommodations to which the Commissioners conceive that their means might legitimately be devoted are, a small landing pier or slip at Fort Augustus for vessels engaged in the local trade, and an embankment track-path on the north-west side of the canal between the Old and the New Gairloch Locks, which are at present connected only on the opposite side. The erection of landing piers at the different points where the steam-boats touch on the Lakes, would be of much convenience, and the accommodation of a graving dock or patent slip for the repair of large vessels at the eastern end of the canal is highly to be desired, but these are rather subjects for individual enterprise.

The sum of 10,000*l.*, granted by parliament for the repair of the damages to the canal works, occasioned by the floods of January 1849, was issued in August last, and there is no reason to doubt that the anticipations of its sufficiency for the entire restoration of the works, and also for the completion of the several precautionary measures above alluded to, will be verified.

With regard to the Crinan Canal, the report states that the condition of this navigation has been much improved by various important repairs. The upper gates of the summit lock at Cairnbaan (No. 8), and also of the second lock at Crinan (No. 14), have been renewed. By means of a small dredging apparatus fitted to the canal barge, an additional depth of near two feet has been gained in the entrance to the canal through the harbour of Ardrishaig, greatly diminishing the period of detention (sometimes five or six hours), long complained of by masters of vessels, especially of steamers, which drawing ordinarily about seven feet water, were previously unable to enter or depart from the canal after half-ebb on the falling tide, or before half-flood on the rising tide. The dredging apparatus has also been usefully applied in restoring the canal to its full depth at spots where, as at Dunardry, the deposit from burns discharging into it had greatly encumbered the bottom. The reduction of dues upon the navigation, which was announced in the last report, has not diminished the revenue, although the tariff of charges on the principal articles conveyed was reduced by nearly one-third. The revised tariff was in force for the last nine months only of the year 1849, during which time the increased resort of sailing vessels produced 1135*l.*, as compared with 1113*l.* in 1848. Out of 729 vessels entering or clearing from the Clyde from or to northern ports, and capable of passing the canal, only 353 (or 48½ per cent.) took the passage round the Mull of Cantyre, whereas in the corresponding period of 1848, that course was adopted by rather more than 62 per cent. of the vessels under similar circumstances. In the months of January, February, and March 1850, this proportion was reduced to about 21 per cent., but it increases as the approach of summer diminishes the danger of the more exposed and circuitous course. The dues on steamboats were not reduced at the time of the revision of the general tariff; but by an alteration sanctioned in the course of the month of May in the present year, the commissioners have authorised a reduction of the tonnage rates leviable upon steamboats from 9*d.* to 6*d.* per ton, and also of the harbour rates at Ardrishaig and Crinan from 1*d.* to ½*d.* per ton.



NEW PARISH CHURCH, SWINDON, WILTS.—GEORGE GILBERT SCOTT, Architect.

NEW PARISH CHURCH, SWINDON, WILTS.

THE annexed engraving is a view of a new church that is now in course of building, under the superintendence of Mr. Scott. The situation is an elevated spot near the town of Swindon, Wilts. The building is of the Decorated period, and constructed with stone, the dressings being of Bath stone worked. The total length of the church is 145 feet; breadth 55 feet. Transepts 80 feet long, and 25 feet wide; height from floor of nave to top of ridge of roof, 50 feet. Tower, 24 feet square; and height, including spire, 145 feet. The church will contain 926 sittings, and the cost between 8000*l.* and 7000*l.*, raised by voluntary subscriptions, and a grant from the Incorporated Church Building Society. The contractor is Mr. George Myers, of the Westminster-road.

BRITISH ASSOCIATION.

Selections from Papers read at the Meeting held at Edinburgh, August, 1860.

ANCIENT GREECE.

Notices of some additions made to our knowledge of the Ancient Greeks by recent discoveries in Greece. By Professor RANGABE, of Athens.

THERE exists one subject—one in particular—by which I may venture to say that Greece must excite to the highest the interest of the learned—namely, that of her ancient monuments, which can never cease to be an object of universal study and admiration; and I may, perhaps, all the more hope to be heard with indulgence, while I attempt to give a short account of the principal facts with which the science of archaeology has been enriched by the discoveries made in Greece since her enfranchisement, that it is to the learned investigations of British antiquarians in particular that is due most of the knowledge we already possess of the Hellenic monuments. Like those towns of Italy which reappear in their ancient splendour when their covering of lava is removed, Greece, as soon as she had shaken off the slavery of so many centuries, offered to the admiration of the world the innumerable treasures of her antique beauty; and her monuments, after having seen so many barbarian conquerors pass over their ruins, and after having been so often exposed to destruction, and after—may not I, whose days are passed among the mutilated remains of the Parthenon, be permitted to say so?—the severe damage inflicted on them by the too fervid zeal of a distinguished amateur, became once more the objects of a renewed worship, as soon as her freedom had rendered Greece accessible to all, and an enlightened government, aided in its efforts by an archaeological society, had restored them to light.

Among these monuments there are many which cannot fail to excite interest in the most indolent imagination. They are those which bring us back to times which we are accustomed to see through the prism of poetry, and which disclose to us at a period antecedent to history, a powerful civilisation—which we find indeed in the songs of Homer, but which we are rather disposed to look upon as an effort of the sublime imagination of that great genius of heroic time.

Before the emancipation of Greece, the traveller, gazing in wonder on the gigantic walls of Tyrinth and Mycenæ, was inclined to ask if their construction was not rightly attributed by fable to superhuman workmen; and, in order to complete the first page of Hellenic ethnography, illustrated by existing monuments, he was obliged to have recourse to the Tyrrhenian towns of Italy.

But the country of Agamemnon, now more easily traversed, and more carefully explored, is found to be covered with a great number of edifices belonging to the time of the *Anaktes*. Captain Sottoux—one of the most indefatigable members of the French commission, which has rendered so great a service to science by its excellent map of Greece—saw in the wild ravines of Arcadia more than thirty foundations of towns, of Cyclopean construction. In Arcadia—the dwelling place of the Pelasgians, who pretended to have seen the creation of the moon, and who at least preceded the Hellenic race—polygonal walls are discovered every day; and in a valley unknown to travellers between the lake Stymphalia and the Mount Trachys of Orahomennus, I had myself the happiness, two years ago, of discovering at the very spot where Pausanias (viii. 23) places it, the town of Halia, long sought for, and not as yet perceived by any of my predecessors. This ruin presents one of the most imposing examples of Pelasgic architec-

ture, and at least two-thirds of it are in a state of rare preservation. Its form is that of a triangle, whose base lies along the foot of the mountain, and whose two sides rise up on its flank. The latter only are standing, and they attain often a height of 16 ft., and contain 37 square towers. A parallelogram traced on the summit of the triangle, forms the acropolis of the fortress, whose walls are composed of gigantic polygonal blocks, and the lintel of whose doors consists of two inclined stones, which mutually support each other.

But in Argolis, the very seat of the power of the Atrides, the discoveries have not been few. At the same time with Halia, I saw in a little valley, separated from the Argolic plain by a rising ground, and quite close to Mycenæ, a square edifice till then unknown, of the finest polygonal style, each side being 36 feet in length, and rising in perfect preservation to the height of 10 feet, where its coping still exists. The interior was divided into three compartments, but the separations are almost entirely destroyed. This monument is one of the most interesting that has yet been discovered, as it discloses to us a particular branch of Homeric architecture. It is difficult to believe that at so short a distance from Mycenæ, an edifice belonging to the class of those which excited so highly the admiration of the ancients, should remain unnoticed by them; I am therefore tempted to suppose that this is no other than the Tower of Polygnotus, as it was called, where Aratus, on his way from Argos to Phlius, had a meeting with his conspirators (Plut. Vit. Arat. 6 and 7).

The famous Temple of Juno at Argos, the scene of the pious exploit of Cleobis and Bion, was discovered after the deliverance of Greece. Under the ruins of a new temple, which had been built about the 90th Olympiad, and magnificently decorated by Polydectus, is to be seen the gigantic foundation of the ancient sanctuary, which was burned about that same period by the negligence of the priestess Chrysis, and is now the only religious ruin, authentically proved, belonging to an epoch anterior to historical times.

I was present at the excavations made at Tyrinth by the illustrious German antiquarian, Thiersch, and I witnessed the highly interesting result which he obtained. On the western side of the hill of the Cyclops, he discovered a range of bases of columns; and this fact, combined with the column already known in the Treasury of the Atrides, and that of the basso-relievo of the lions at Mycenæ, tend to modify the ideas held until now on Pelasgic architecture, and to prove that the principle of the columns—of a primitive form, undoubtedly, but containing the germ of the diverse forms developed later by the Dorians and Ionians—was, if not an indispensable part, at least an ornament frequently employed in the buildings of Homeric times. Another discovery of the highest importance to the architecture and ethnological history of that remote period has just been made in the south of Eubœa. Walpole had already seen and described (Travels vol. i.) on the summit of Mount Ocha, an edifice of a peculiar form and of an archaic style. Its walls are composed of very large parallelogramical blocks, of unequal dimensions; and its roof consists of several layers of stones, which advance on each side towards the centre, jutting out considerably the one beyond the other, instead of forming a smooth surface as in the Treasury at Mycenæ. But from this specimen of architecture, curious as it was from its differing from the usual forms of ancient art, no conclusion could be drawn to further our knowledge of that art, because it only furnished one isolated example. But at Styra, the town famous for its quarries, situated at the northern foot of the same mountain, the discovery was made a few years ago, of three buildings of the same nature, one of which is peculiar for its roof being circular. On another peak of Mount Ocha, I myself visited, only last summer, several edifices, the evident remains of a very ancient town, suspended on the brink of an abyss equally inaccessible by sea or by land, and known only to the shepherds of those wild regions, who give it the name of *Archampolis*, or ancient town. These buildings are constructed on the same architectural principles; and I have heard another position described not far from the Cavo d'Oro, as the Venetians called the Capharea, where more such ruins exist. It is very remarkable that all these constructions, which, though belonging to the general system of Pelasgic architecture, differ sufficiently from it to contribute a class apart, are all found grouped in so considerable a number on one point of Greece; and this circumstance leads one to presume, that this style belongs properly to some tribe, which, having its principal seat in the deep valleys of the Ocha, emanated, like all those which occupied in heroic times the soil of Greece, from the common stock of the Pelasgians, but which had a character sufficiently distinct from

the other branches, to have developed the art of building in a particular sense. And in this race, in my opinion, we may recognise the *Dryopes*, who, in the most remote times, expelled from their ancient seats in Thessaly, came to occupy the southern part of Eubœa, just the spot where these constructions of so ancient a style, and so distinct from all other examples offered to us by history, have been discovered.

But the discoveries made in Greece since her emancipation have not less served to rectify and to extend the notions already possessed on *Classical Architecture*. The Propylea having been disencumbered from the modern fortifications which concealed them from view, and having now re-appeared in all their ancient harmony, it is easily recognised that their magnificence corresponded fully with that of the immortal monuments to which they gave access, and that their superb flight of steps occupied the whole width of the entrance to the Acropolis, descended probably to the Agora, and was ornamented on either side by terraces supporting statues and temples. One of the latter, the Temple of Victory, without wings, the finest jewel of the Acropolis' crown of monuments—which had disappeared between 1676, when Spon and Wheeler travelled in Greece, and 1751, when Stuart visited it—now discovered again under a Turkish bastion, and restored, offers to study one of the purest and most perfect examples of the tetrastyle amphiprostyle of the Ionic order which exists in the world. The mouldings of its entablature, as well as those of the Propylea and of the Parthenon, bear evident traces of painted ornaments, and put it beyond all doubt that the ornamental parts of the temples were painted in Greece, like those of Sicily, in the time of Pericles, as well as at more ancient periods, when they were often replaced by terra-cotta. In the Pinacothek, which contained the famous pictures of Protogenes, the walls which the French or Catalanian dukes had constructed to convert this part of the Propylea into their Chancery having been destroyed, the original partitions have been brought to light; and I think that the examination of these and of the walls of the Temple of Theseus, may give the solution of the question which had been the subject of so much controversy—namely, whether the ancients painted exclusively on the walls or on panels of wood, by proving that the Pinacothek was covered with panels, or, rather, moveable pictures; whereas the paintings in the Temple of Theseus were executed on stucco fixed to the wall itself. And I may here mention that one of the greatest connoisseurs of the paintings of the ancients—M. Raoul-Rochette, of the Institute of France, is now occupied in putting together all the recent information obtained on this subject, with the intention of working it into a special treatise.

The Parthenon, in spite of the exact and conscientious work of Cockerell, when delivered of the barbaric ruins which insulted its grandeur, had still secrets to disclose; and it is well known that attentive observations have taught the astonished architects of modern times, that of all those lines whose magnificent harmony is the source of the inimitable beauty of this edifice, there is not one which is a straight line; that with a depth of science which would put to fault the calculations of the profoundest mathematician, the architect, imitating nature, who avoids a straight line in her organic productions, had composed a system of curves beyond the skill of modern art to combine or reproduce.

The Erechtheum, that enigma of architecture, can also be better understood since it has been raised from its ruins; and in my opinion it is now evident that this temple was double, in spite of its having four names, and that the singular distribution of the house consecrated to Erechtheus which it replaced had been adopted in its construction. The new notions obtained on this temple have been most ably discussed in the *Annals of the Academy of Munich*, by the most learned philologist of Germany, M. Thiersch, who is now preparing a second work on the same subject.

To the study of Sculpture the results have not been less important. Each fragment fallen from the chisel of a great master, and now withdrawn from the dust, is an inestimable treasure. The excavations made around the Parthenon have augmented our glyptic riches with twenty-one pieces of the frieze, one metope, and six large fragments of statues belonging to the front of the temple, all master-pieces, which serve, in a slight degree, to console the Greeks for the painful losses made at a time when it was not in their power to prevent them. I may say as much for the blocks of the frieze of the Temple of Victory, which are the completion of those carried away by Lord Elgin. The discovery of the frieze of the Erechtheum is not a less precious one; its existence even was unknown, when twenty-one small statues of equal dimensions were found in the rubbish. They are of white

marble, and having the back part of each quite flat, were evidently applied to and detached themselves from a back-ground of Eleusis stone. The execution is of the purest style; and they allude, I think, to the procession of the Pandrosus, to the birth of Erichthonius, and to the loves of Mars and Mercury with Agraulis and Herse.

I shall not enter into a detailed enumeration of all the invaluable pieces of sculpture which have been gathered into the Museum of Greece. But there are several which have enriched antiquarian knowledge with entirely new facts. It is thus that a very remarkable low relief, found in a cemetery on the east coast of Attica, and representing a warrior larger than life, serves as a precious stepping-stone for the history of art among the ancients, by affording a very important specimen of the archaic school of Athens, and particularly of the manner of *Aristocles*, whose name is inscribed on it, and who, according to my idea, flourished about the 66th Olympiad. Having come from Sikyon, where his grandfather had established himself after leaving Crete, this artist may be considered as representing the connection between the different schools of archaic art. This fine low-relief also teaches us, that at the most remote period the same habit existed, which continued in later times, of painting works of sculpture, or at least the ornamental parts and accessories of them.

Among the inscriptions recently discovered, and which serve to extend our archaeological information, I shall only mention the most important to the history of art, such as those which give us new details on the epoch and the works of divers sculptors. It is thus by one of them we learn that *Eudamos*, thought to be the pupil and relation of *Dedalus*, was, in fact, only a *Dedaidos*, an artist of the archaic school, and not more ancient than *Aristocles*. We learn from another, the existence of a sculptor of the same epoch, named *Nesiotes*; and from a third, that it was *Strongyliion* who executed the famous *Durion* horse on the Acropolis.

Among those which throw a stronger light on the public life of the ancients, I shall mention one which, consisting of more than 180 fragments, contains the list of the allied towns which paid tribute to Athens. The knowledge of these enriches ancient geography with a number of names unknown until now, and completing the political history of Athens, gives a more exact idea of its greatness. The tribute-money seems to be calculated for a month, and the list only to contain the tenth part, or the share belonging to the temple. As far as the mutilated state of these fragments permits one to judge, that share seemed to have amounted to nearly five talents and a-half a month. Several other inscriptions complete the lists already known of the treasures contained in the Parthenon, and the result to be obtained from them is, that in the days of the splendour of Athens, the temple contained objects in silver and gold, weighing together about 17 talents of silver. From another of these inscriptions, we can calculate the rate of interest paid to the Parthenon when the funds of the temple were lent to the town. I estimate this rate at 10 drachmas per 50 talents every day, or 1½ per cent. for a year. Other inscriptions not less precious, which have served as a basis to the learned work of M. Boeckh, throw a great and new light on the most powerful element of Athenian greatness, the organisation and importance of their navy. The expense of the first expedition to Corkyra (Corfu), which opened the Peloponnesian war, forms the subject of one of them; and I pass over in silence a great number of monuments illustrative of more than one important point of history, such as the political calendar of the Athenians; their relations with foreign princes and nations; the detailed organisation of the *Amphiktyonic* league; the position of private slaves, and of the *hierodules*, or servants of the temple; questions of topography and others relating to the public games.

I have only mentioned the discoveries the most rich in results, and the principal contributions which Greece has brought to the science of antiquity since her emancipation. And if it is true that my account is still far beneath the reality, and that a very abundant source of archaeological knowledge, obstructed by the ruins under which centuries and barbarisms had buried it, has now been reopened in Greece by the power of liberty, and by the enlightened efforts of a regular government, I hope I shall be allowed by the lovers of antiquity to advance, that the emancipation of Greece has not been a regrettable event, as some seem to have wished to make it appear, and that Greece has by this return alone repaid the greater part of the sacrifices made in her favour.

INCORUSTATION IN STEAM BOILERS.

On the Incrustation which forms in the Boilers of Steam-Engines, in a letter addressed to Dr. G. Wilson, F.R.S.E. By Dr. J. DAVY.

On entering on this inquiry, which I did after my return from the West Indies in December, 1848, and after communicating a short paper to the Royal Society "On Carbonate of Lime in Sea-water," it appeared to me desirable to collect as many specimens as possible of incrustation from the boilers of steam vessels, now so widely employed in home and distant navigation. By application to companies and to friends in our sea ports, as Dundee, Hull, Southampton, Hayle, Liverpool, Whitehaven, I have succeeded in procuring specimens of incrustation formed by deposition in voyages from port to port, in the British and Irish Channels, and the North Sea, between Southampton and Gibraltar, in the Mediterranean and the Black Sea, and in the Atlantic Ocean, between Liverpool and North America, and between Southampton and the West Indies. I am promised specimens from the Red Sea and the Indian Ocean—but these I have not yet received.

The character and composition of the incrustation, whether formed from deposition from water of narrow seas or of the ocean, I have found very similar—with few exceptions, crystalline in structure, and, without any exception, composed chiefly of sulphate of lime; so much so, indeed, that unless chemically viewed, the other ingredients may be held to be of little moment, rarely amounting to 5 per cent. of the whole. From two specimens of incrustation from the boilers of steamers crossing the Atlantic, one of which you sent me, in which you had detected a notable portion of fluorine, judging from its etching effect on glass,—I also procured it, it was in combination with silica; and procured it also so combined from two obtained from steamers navigating our own seas, one between Dundee and London, the other between Whitehaven and Liverpool. Of this I had proof, by covering with a portion of glass or platinum foil a leaden vessel charged with about 200 grains of the incrustation mixed with sulphuric acid, and by keeping the glass cool by evaporation of water from its surface, and by supplying moisture for the condensation of the silicated gas by a wet band round the mouth of the vessel. After about twenty-four hours under this process, a slight but distinct deposition was found to have taken place, corresponding to the margin of the vessel—a deposition such as that produced by silicated fluorine acid gas under the same circumstances. Thus it was not dissipated by heat nor dissolved by water, and yet admitted of removal by abrasion, either entirely or in great part; the former in the instance of the platinum foil, the latter in that of the glass. Besides the ingredients above-mentioned, I may add that, in many instances, oxide of iron, the black magnetic oxide, was found to form a part of this incrusting deposit, collected in one or more thin layers, and further, that in some, especially of steamers navigating the narrower and least clear part of the British Channel, the depositions presented a brownish discolouration produced by the admixture of a small quantity of muddy sediment. Incrustations so discoloured, I may remark, are reported to be most difficult to detach.

I have said that the incrustations, with few exceptions, were similar in their structure, and that that was crystalline; it was not unlike the fibrous variety of gypsum of the mineralogists. The specimens received, as might have been expected, varied very much in thickness—viz., from one line and less to half an inch. I have endeavoured, by a set of queries which I had distributed, to obtain information respecting the exact time in which the incrustations were formed, and under what circumstances; but with partial success only, owing to a want of exact observation. In one instance, that of the North American mail-ship *Europa*, which arrived at Liverpool on the 15th of November, at 4 p.m., having left Boston on the 7th of the same month at 9 a.m., an incrustation was found in her boiler of about one-fiftieth of an inch in thickness; and it is stated that an incrustation of about the same thickness was found on her outward voyage. This example may aid in giving some idea of the degree of rapidity with which the incrustation is produced, at least in the Atlantic, with the precaution of "blowing-off" every three hours, and with the "brine pumps" kept in constant work. In other seas, especially contiguous to shores, and more especially of shores formed by volcanic eruptions, it is probable, *ceteris paribus*, the rate of the deposition of the incrusting sulphate of lime will be more rapid. The results of the trials of several portions of sea water taken up on the voyage from the West Indies to England noticed in the paper of mine already referred to, are in favour of this conclusion.

To endeavour to prevent the deposition of the incrusting matter or to mitigate the evil, various methods, it would appear, have been had recourse to—some of a chemical kind, as the addition of muriate of ammonia and sulphate of ammonia to the water in the boiler—without success, as might be expected; others, of a mechanical kind, with partial success—as the introduction of a certain quantity of saw-dust in the boiler, or the application of tallow, or of a mixture of tallow and plumbago to its inside, to prevent close adhesion, and the more easy separation of the incrusting matter either by percussion, using a chisel-like hammer, or by contraction and unequal expansion, by means of flame kindled with oskum, after emptying the boiler and drying it. Of all the methods hitherto used, that of "blowing-off"—that is, the discharging by an inferior stop-cock a certain quantity of the concentrated water of the boiler by the pressure of steam, after the admission above of an equivalent quantity of sea water of ordinary density, appears to be, from the reports made, the most easy in practice, the least unsuccessful, and the most to be relied on. But, as in the instance given of the North American steamer, it can be viewed only as a palliation.

Considering the composition of the incrusting matter and the properties of its principal ingredient—the sulphate of lime, a compound soluble in water and in sea water, and deposited only when the water containing it is concentrated to a certain degree, there appears to be no difficulty theoretically in naming a preventive. The certain preventive would be the substitution of distilled or rain water in the boiler for sea water. Of this we have proof in the efficacy of Hall's condenser, which returns the water used as steam, condensed, after having been so used; but, unfortunately for its practical success, the apparatus is described as being too complicated and expensive for common adoption. Further proof is afforded in the fact, that the boilers of steamers navigating lakes and rivers in the waters of which there is little or no sulphate of lime, month after month in continued use, remain free from incrustation. This I am assured is the case with the steamers that have been plying several summers successively on the lake of Windermere. And it may be inferred, that in sea-going steamers in which sea water is used in the boiler—or, indeed, any water containing sulphate of lime, the prevention of deposition may be effected with no less certainty by keeping the water at that degree of dilution at which the sulphate of lime is not separated from the water in which dissolved.

From the few trials I have made, I may remark, that sulphate of lime appears to be hardly less soluble, if at all less, in water saturated with common salt than in perfectly fresh water. This seems to be a fortunate circumstance in relation to the inquiry as to the means of prevention, and likely to simplify the problem. If these principles be sound, their application under different circumstances, with knowledge and judgment on the part of the directing engineer, will probably not be difficult. His great object will be in sea-going steamers to economise the escape of water in the form of steam, and thereby also economise heat and fuel; also, when fresh water is available, to use it as much as possible; and further, to avoid using sea water as much as possible near coasts and in parts of seas where sulphate of lime is most abundant. From the incrustation on the boilers of sea-going steamers, the attention can hardly fail to be directed to that which often forms, to their no small detriment, in the boilers of locomotive-railway engines, and of engines employed in mines and in the multifarious works to which steam power is now applied. These incrustations will of necessity be very variable, both in quantity and quality, according to the kind of ingredients held in solution in the water used for generating the steam.

Hitherto I have examined two specimens only of incrustations taken from the boilers of locomotive engines, and a single one only from the boiler of a steam-engine employed on a mine—a mine in the west of Cornwall. The latter was fibrous, about half an inch thick, and consisted chiefly of sulphate of lime, with a little silica and peroxide of iron, and a trace of fluorine. The former were from one-tenth of an inch in thickness to one inch. They were laminated, of a grey colour, and had much the appearance of volcanic tufa; they consisted principally of carbonate and sulphate of lime with a little magnesia, protoxide of iron, silica, and carbonaceous matter—the last two, the silica and carbonaceous matter, probably chiefly derived from the smoke of the engine and the dust in the air. From the engineer's report it would appear that the thinnest—the incrustation of about one-tenth of an inch—had formed in about a week, during which time the locomotive had run about 436 miles, and consumed about 10,000 gallons of water.

IRON FORGING.

Improvements in Forging Iron. By JAMES NASMYTH.

Before proceeding to describe the nature of the improvements in question, Mr. Nasmyth made some remarks on the value and importance of any improvement which tended to increase the certainty of the production of sound and perfectly solid forgings of wrought-iron, more especially those massive forgings required for such purposes as paddle-shafts, marine engines, crank and plain axles for locomotive engines, anchors, and such like, on the soundness of which both life and property to a vast amount may depend.

Mr. Nasmyth instanced cases in which paddle-shafts of marine engines had given way, although in the first instance they had all the outward aspect of the most perfect soundness, but which on fracture exhibited the existence of original defect, in being little else internally than a mass or bundle of loose bars of iron, which had never been in a sound welded union, but had only been held together by the exterior, where alone the welding had been so far perfect.

Mr. Nasmyth exhibited a diagram of which fig. 1 is a copy, in order to illustrate the action induced on the centre portion of a cylindrical forging, when produced under the action of a flat-faced hammer and anvil.

It will be seen at once that the action induced on the centre portion of the metal of a shaft, or such like cylindrical form, by the successive blows of a flat-faced hammer and anvil, as *a* and *a* is to cause the work to spread out or extend in the direction *a n*, *n c* (as represented by the double-headed arrow on the figure); and as the flattened-out form has to be attempted to be corrected by turning the shaft round and round on the anvil, so that each successive blow may be made to correct the spreading out caused by the previous blow. The result of this action is a fretting or mincing of the centre part of the metal of the shaft, resulting in a separation of the metal throughout the entire centre portion of the shaft, somewhat after the manner indicated in fig. 2, frequently to such an extent as to permit the passage of air or water from end to end of shafts forged in this manner.

The effect of this kind of unsoundness is that it is certain, sooner or later, to work out towards the exterior, and in all probability result in a break down more or less disastrous in its consequences.

Mr. Nasmyth then proceeded to describe his improved form of anvil-face, by the employment of which all such defects as detailed above are avoided. Such has been the perfect success and excellent results which have attended the use of his improved anvil-face, that its adoption has become almost universal; and the production of absolutely sound solid wrought-iron shafts, of whatever magnitude, rendered equally easy as certain.

4, (fig. 3) represents the form of Mr. Nasmyth's improved anvil-face, which he terms a V-anvil, between the jaws of which the work to be hammered is placed as indicated by a cylindrical shaft, seen in section marked *c c c*.

A glance at the above figure will, no doubt, render its action evident, namely, that the action of each blow of the hammer on the work *c o c*, instead of causing, as in the case of fig. 1, a di-

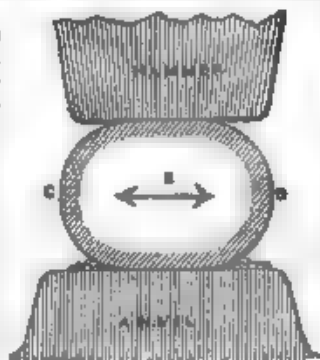


Fig. 1.



Fig. 2.

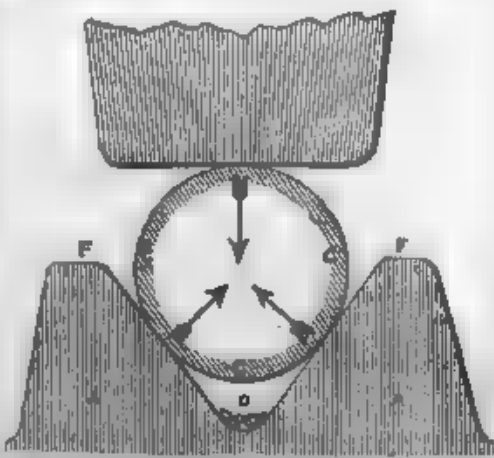


Fig. 3.

verging action on the centre portion of the work, occasions, on the contrary, a converging action, as represented by the three arrows; and instead of having the centre portion of the metal of the shaft rendered less compact and solid by the action of the blows of the hammer, we have quite the contrary effect produced; besides which, owing to the wedge-like form and action of this V-anvil face, the compressing effect of the blows are most importantly enhanced, and the ease and rapidity with which such cylindrical-formed work as shafts and the like can be produced under or by such means is most remarkable; so much so as to enable the fergemen to hammer out at one heat, by means of this V-anvil, as much as would require three heats on the common flat-face anvil. Add to which the vast convenience which the fork-like form of the V anvil yields in keeping the work at all times right under the centre of the hammer, as it is turned round and round to receive the successive blows, which in the case of work of the largest class is a matter of no small trouble; another advantage consists in the free passage or exit which is at all times preserved for the escape of the scales and impurities which fall from the hot iron during the process of hammering, which scales fall down towards the apex of the V at *n*, and trickle away, thus removing the cause of blennish and roughness which is caused by such scales collecting on the face of the flat anvil, and get beat into the surface of the forging.

It will be seen on inspecting fig. 3, that one such V-anvil face as there represented, will accommodate a vast range of diameters of work—namely, all variety of diameters, such as will neither absolutely rest on the bottom of the apex at *n*, or on the corners *p* & *q*.

Mr. Nasmyth has taken every means, by the most free communication, to promulgate among those interested the advantages of this V-anvil, and has been rewarded by seeing its use become almost universal.

Mr. N. stated that an angle of 90° was found by him to be most generally suitable for the inclination of the sides of the V, and also that the edges should be well rounded off, and the surface of the V sides curved in the direction of the axis of the work, to the extent of $\frac{1}{4}$ th of an inch in 12 inches, so as to be "proud" in the centre, and so facilitate the extension (axis ways) of the work. The vast simplicity, as well as the important results, which are yielded by the employment of this V-anvil face, has, in no small degree, contributed to its almost universal adoption. Its employment renders the production of perfect sound work as easy as certain.

Mr. Nasmyth next proceeded to describe the second part of his improvements in forging iron, which consist as in the first case, of means equally certain and simple in producing sound boiler plates. Mr. Nasmyth prefaced his description of his improvements on this truly important subject by detailing the nature of the most frequent causes of unsoundness in iron forgings generally, and in boiler plates in particular, namely, the imperfect expulsion of the molten oxyd of iron, or "scoria," or "cinder," as it is termed, which in every case of welding hot iron covers and clings to the surface of the metal; and if left interposing between the welded surfaces, is certain to occasion a defect greater or less according to the surface of junction it occupies. The frequency of this interposing scoria as the true cause of unsound forged work was forcibly alluded to by Mr. Nasmyth, and shown to be the most fertile source and cause of the failure of wrought-iron work, resulting as such too frequently does, in the most sad and disastrous accidents, such as the failure of the links of chains and anchors, and in the costly and often distressing results arising from defective, i. e. blistered boiler plates.

In respect to the links of chains, Mr. Nasmyth mentioned as the result of an extensive series of experiments on the strength of chain cables, on which, as member of "the committee on metals," he was employed by the Admiralty; out of every ten cases of fracture, eight were occasioned by defective welding, as evinced by the appearance of the surfaces, which present to a practical eye appearances not to be mistaken, owing to the very peculiar aspect of the surface of the apparently welded metal, between which surfaces the oxyd or scoria had not been duly expressed.

Mr. Nasmyth further described the condition absolutely requisite to perfect welding, namely, not merely that the surfaces we desire to weld should be really "welding hot," but also that when brought into contact, no particle of the scoria, which inevitably clings to the metal while welding hot, should be permitted to remain interposing between such surfaces as we desire to weld. If such material is left interposing, we are certain to have defect and unsoundness to a greater or less extent as the result.

In order the more clearly to detail his improvements on this important subject, Mr. Nasmyth exhibited a coloured drawing

representing the usual form and arrangement of "a pile" of "slabs" such as are employed in forming, when welded together, a mass of iron from which boiler plates or bars of iron are rolled. Fig. 4 represents such "a pile" of "slabs," which having been, as is generally the case, produced under the action of a forge hammer and anvil, having flat, or as is generally the case, slightly convex surfaces, causes the slabs so produced to have certain hollow parts, or slightly concave portions of their surfaces, so that when piled one upon the other, as in fig. 4, the risk of having hollow spaces between is almost certain. The hollow spaces are represented in the figure by the dark irregular lines between the slabs.

Referring to fig. 4, A, B, C, D, represent a pile of four slabs laid on the anvil welding hot; owing to the concave irregularities of the surfaces, the parts most certain to come into contact first are generally the exterior edges of the slabs. The effect of the blows of the hammer is first to weld the parts in natural contact; and by continuance of the blows, the interposing scoria or "cinder" is expressed, in a degree more or less perfectly, according to the energy of the blows and the deepness of the convex or hollow patches between the slabs. So long as there exists an exit or passage for this scoria, all is well; but, as generally happens, some portion of this scoria lurks behind after all chance of escape is removed by the welding of the exterior portion of the surfaces of the slabs. The result of this is, that we have to a certainty a defect greater or less in amount, according to the quantity or surface over which the inclosed scoria extends: once such scoria is shut up between the surface of the slabs, no amount of after hammering will ever expel it, but on the contrary, will only tend to its extension over a larger surface; and, as before said, so long as a particle of this scoria is left interposing, so have we a degree of unsoundness in proportion.

Great as this evil is, and common as it is as a fertile cause of defective iron work, and the more especially so in the case of boiler plates, the means of avoiding such source and cause of defect is as simple as the results are important; and it is to be hoped that the free and open communication which Mr. Nasmyth has made of his views on this subject will be answered in the most acceptable way by the general adoption of his improvement or certain means of avoiding the occurrence and existence of all such causes of defective boiler plates, and forged work generally; which improvements consist simply in so forming the surfaces which we desire to weld together that a free exit may be preserved to the last for the escape of the molten oxyd or scoria until the entire surface of the parts we desire to weld are thoroughly incorporated by the welding property, aided by the action of the hammer or rolls, as the case may be.

In order to accomplish this most important and desirable object, Mr. Nasmyth forms the surfaces of his slabs convex (see fig. 5); by which most simple common-sense means a perfect free exit to the scoria or interposing impurity is maintained to the last moment, the welding commencing at the centre part of contact w, and extending outwards towards the edges under the action of the successive blows of the hammer, or squeeze of the rolls; but, as before said, an open door is kept for the escape of the scoria until the surfaces unite from the centre w to the outer edge z, z, z. Here, then, by an arrangement or formation of the surfaces we desire to weld, we have the most certain and simple means of procuring a perfectly solid sound mass of iron which, when beaten, hammered, or rolled down to whatever thickness we desire, will retain, to the last, all the qualities of the one sound

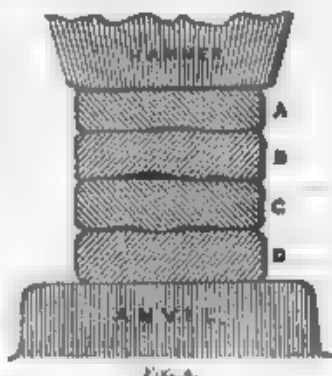


FIG. 4.



FIG. 5.

solid mass we had converted it into by this most simple improvement—namely, giving to the surfaces we desire to weld a convex form and relation to each other.—Mr. Nasmyth concluded his observations on these important subjects by an earnest appeal to the members of the Mechanical Section to diffuse, by all means in their power, the information which, on this as on all such subjects, he shall ever feel the highest pleasure in communicating to the practical men of his profession, and the world in general, who may think fit to accept these results of an active life, which he finds so much real pleasure in freely sharing with them.

POWERS OF MINUTE VISION.

On the Powers of Minute Vision. By Mr. W. PATRICK.

RESULTS from experiments for determining the best sort of station-marks, and the errors liable, in observing with optical instruments that measure on the principle of bringing two reflections together. The experiments were performed in bright daylight (but not sunshine), being light of the maximum of advantage for perceiving black against a white ground. The general circumstances of the experiments were arranged rather to determine the facts of common practice, than the theoretic powers of vision.

Mr. Patrick then detailed the various distances at which circular spots, lines, &c., white on black as well as black on white, could be seen, the distances being given in terms of the breadth of the object seen. An arrangement of lines was described, by which an alteration of their position to the extent of only one millionth part of the distances of the observer was made visible. One result of the experiments would be to show what would be the proper proportions of parts to be observed in forming letters to be read with the greatest distinctness at a distance,—a subject of much practical use in the present day, and admitting of a strictly scientific system, although generally left to the fancy of incompetent persons. White letters on a black ground should have their component lines of only half the breadth that black letters should have on a white ground.

The direction of the eye, while appearing to gaze steadily at any object, does in reality keep wandering to an imperceptible distance on every side of the object looked at, but very rapidly. This wandering is not accidental or an imperfection of sight, but an essential feature of vision; because it is not the continuance of an impression that is perceived (by any of the animal nerves), but its commencement and termination, or, more strictly speaking, its increase and decrease. This principle is probably analogous to that by which a magnet creates an electric current in a neighbouring wire, not by its constant presence, but by the increase or diminution of its influence, either by a variation of its power, or of its position.

This wandering propensity of the eye was shown to account for the relative facility with which different sorts of marks were seen at great distances: it takes place, apparently, in a minimum case, to the extent of an angle of 1 in 2500. A dislocated line (as in a vernier), its fault being half its breadth, can be perceived to be so at a distance of 10,000 times its fault, if black on a white ground; and at 12,000 times, if white on a black ground. It shows itself, however, by giving the line a less steady appearance, than a perfectly even line would have, when narrowly watched, by running the eye along the line, at about half as far again.

Experiments were then described, on the visibility of the positions of the ends of lines, and of hiatuses in lines, and of square dots as compared with round. But the last conclusion of practical importance was in respect of observing the angular position of station-marks, or of stars, by reflection, as in a sextant. From these experiments it appeared that the position of two closely adjacent dots or images, in sensible parallelism to a given direction, while it affords one of the simplest kinds of observation, is more accurately observable than their actual coincidence, or even than the junction of two lines, as if in a vernier.

On the Gradual Subsidence of a Portion of the Surface of Chat Moss, in Lancashire, by Drainage. By Mr. G. W. OSWENSON.—This was the continuation of a paper read at the Swansea Meeting. It was shown by a series of levellings made in the last four years, over an extent of about 900 acres, where drainage was carried on, that a subsidence had taken place to the amount of one inch per annum.

ELASTICITY OF SOLIDS.

On the Laws of the Elasticity of Solids. By W. J. MACQUORN RANKINE, C.E., F.R.S.E.

THIS paper is intended to form the foundation of the theoretical part of a series of researches on the strength of materials. Its immediate object is to investigate the relations which must exist between the elasticities of different kinds possessed by a given substance, and between the different values of these elasticities in different directions.

The different kinds of elasticity possessed by a solid substance are distinguished into three, viz.:—First, *longitudinal elasticity*, representing the forces called into play in a given direction by condensation or dilatation of the particles of the body in the same direction; Secondly, *lateral elasticity*, representing those called into play in a given direction by condensation or dilatation of the particles of the body in a direction at right angles to that of the force; and thirdly, *transverse elasticity or rigidity*, being the force by which solid substances resist distortion or change of figure, and the property which distinguishes solids from fluids. The author's researches refer chiefly to substances whose elasticity varies in different directions. His first endeavour is, to determine the laws of elasticity of such substances, so far as they are independent of hypotheses respecting the constitution of matter; a course which has not hitherto been followed.

The first Theorem or law states the existence of three axes of elasticity at right angles to each other at each point of each substance possessing a certain degree of symmetry of molecular action. The elasticity of a body, as referred to these three axes, is expressed by twelve coefficients, three of longitudinal elasticity, six of lateral elasticity, and three of rigidity, which are connected by the following laws.

Theorem II. The coefficient of rigidity is the same for all directions of distortion in a given plane.

Theorem III. In each of the co-ordinate planes of elasticity, the coefficient of rigidity is equal to one-fourth part of the sum of the two coefficients of longitudinal elasticity, diminished by one-fourth part of the sum of the two coefficients of lateral elasticity in the same plane.

The investigation having now been carried as far as is possible without the aid of hypotheses, the author determines in the first place the consequences of the supposition of Boscovich, that elasticity arises solely from the mutual action of atomic centres of force. In the following theorems a perfect solid means a body so constituted.

Theorem IV. In each of the co-ordinate planes of elasticity of a perfect solid, the two coefficients of lateral elasticity, and the coefficient of rigidity, are all equal to each other.

Theorem V. For each axis of elasticity of a perfect solid the coefficient of longitudinal elasticity is equal to three times the sum of the two coefficients of rigidity for the co-ordinate planes which pass through that axis, diminished by three times the coefficient of rigidity for the plane normal to that axis.

Thus in perfect solids all the coefficients of elasticity are functions of three independent coefficients—those of rigidity. In no previous investigation has the number of independent co-efficients been reduced below six.

To represent the phenomena of imperfect solids, there is introduced the hypothesis of molecular vortices, in addition to that of atomic centres; that is to say, each atomic centre is supposed to be surrounded by a fluid atmosphere, retained round the centre by attraction, and diffused from it by the centrifugal force of revolutions constituting heat. The author has already applied this hypothesis to the theory of the elasticity of gases and vapours. (Trans. Roy. Soc. Edin., Vol. XX. Part I.) Applied to solids, it leads to the following conclusions:—

Theorem VI. In an imperfect solid, each of the coefficients of longitudinal and lateral elasticity is equal to the same function of the coefficients of rigidity which would have been its value in a perfect solid, added to a coefficient of fluid elasticity which is the same in all directions.

Thus the number of independent coefficients for such substances is four.

The rest of the paper is occupied by the deduction from these principles of some important consequences, relative to coefficients of compressibility and extensibility, and to elasticities corresponding to directions not coinciding with either of the three axes.

FORCE OF WAVES.

Observations on the Force of the Waves. By THOMAS STEVENSON, F.R.S.E., Civil Engineer.

THE author, after some introductory remarks, described the action of the Marine Dynamometer, the self-registering instrument with which the observations were made, and one of the instruments was exhibited. He stated, that a theoretical objection might, perhaps, be started to referring the action of the sea to a statical value, but contended, that in designing sea works the attempt of the engineer is to oppose the dynamical action of the sea by the dead weight or inertia of the masonry, so that the indications of the Marine Dynamometer furnish exactly the kind of information which the engineer requires. The greatest result registered in the Atlantic Ocean was at Skerryvore, during the westerly gale of the 29th of March, 1845, when the force was 6083 lb., or 3 tons per square foot. The greatest result registered in the German Ocean was 3013 lb., or about $1\frac{1}{4}$ ton per square foot. It further appeared, from taking an average result for five of the summer months during the years 1843 and 1844, that the force in the Atlantic Ocean was 611 lb. per square foot, while the corresponding average for six of the winter months was 2086 lb., or three times as great as in summer. These observations he had communicated in 1845 to the Royal Society of Edinburgh, and were printed in the twelfth volume of the 'Transactions' of that body.

The author then stated, that the greatness of those results had excited surprise in almost all to whom they had been communicated, and positive doubts were expressed by many as to the correctness of the indications. Three classes of facts, essentially different from each other, may be appealed to, as proving that if the indications of the Dynamometer are incorrect, the error must be in defect, and not in excess. The first fact to which reference was made was the elevation of spray caused by waves meeting with an obstruction to their onward motion. Most persons are familiar with the frontispiece representations of the Eddystone and Bell Rock Lighthouses during storms, which are attached to the descriptive accounts of the erection of those works; and although some deduction may be allowed for the fancy of the artists, still there can be no doubt that they are, in the main, faithful representations of a natural phenomenon. On the 20th of November, 1827, in a heavy ground swell after a storm, solid water rose at the Bell Rock, 106 feet above the level of the sea, irrespective of the depth of the trough of the wave. Such an elevation is due to a head of water of the same height. The force, then, which urges the lower courses of the Bell Rock must have been nearly three tons per square foot, while the highest indication of the Marine Dynamometer at the same place, since the observations were commenced hardly equalled $1\frac{1}{4}$ ton. The second class of facts to which the author alluded was the fracture of materials of known strength. The instance adduced was a small harbour in Argyllshire, where, in order to preserve the tranquillity of the tide basin, a contrivance, called 'booms,' well known in harbour architecture, had been resorted to. The booms are logs of timber, which are placed across the entrance to a harbour, and fit into checks or grooves, which are made in the masonry on either side. The booms, therefore, act as a temporary wall or barrier against the waves. The set of booms referred to have been in use for about five years, and in that time the waves have broken no less than four Menai logs, measuring each one foot square in the middle, and spanning an entrance of 20 feet. From the known strength of the material it will be found, that on these four occasions a force must have been exerted equivalent to the uniform distribution of a dead weight of 30 tons, or at the rate of $1\frac{1}{4}$ ton per square foot, while the highest result that had been recorded at the same place during the short period that observations were made, was about $1\frac{1}{4}$ ton per square foot.

The last class of effects to which the author alluded was the movement of heavy blocks of stone. The information derived from such observations was not so certain or satisfactory as from the other instances. The only record he could adduce was the movement of a block of stone weighing about $1\frac{1}{4}$ ton, to which a Marine Dynamometer had been bolted. The stone was turned upside down, and the dynamometer indicated a pressure of little more than one ton.

The author then referred to the overturning of the Carr Rock Beacon by the sea in 1817, during a heavy gale, but stated that, as we do not know the manner in which waves act when encountering obstacles, it was impossible to calculate what force had in this instance been exerted. The part of the column which was over-

turned was 36 feet in height, and 17 feet in diameter at the base, the rock being so small as to preclude a greater diameter. The author then concluded by stating the following desiderata, which he thought important:—

- 1st. Continued observations so as to ascertain constants for the Atlantic and German Oceans and the Irish Sea.
- 2nd. Relative forces of the same wave both above high-water and below low-water levels. And
- 3rd. Relative forces of the same wave against vertical and sloping surfaces.

AIR AND WATER IN TOWNS.

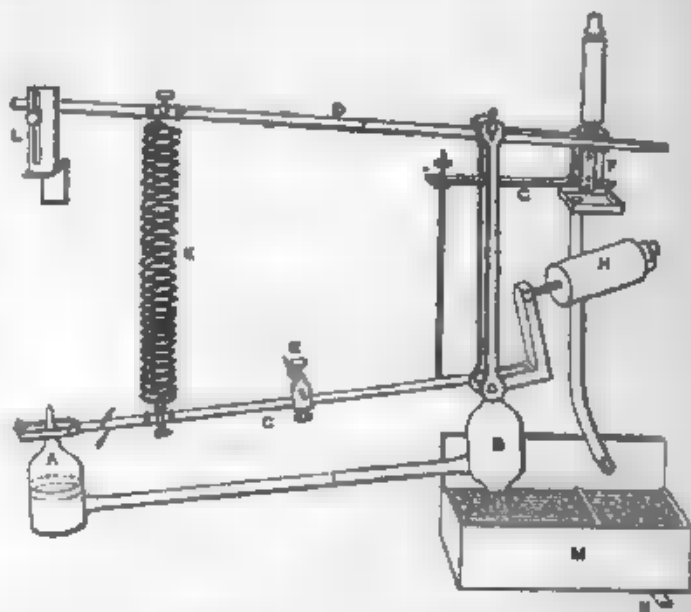
On the Air and Water in Towns, and the action of Porous Strata on Water and Organic Matter. By Dr. R. A. SMITH.

It is a matter of great importance to find from what source it is best to obtain water for large towns, and how it is to be collected. To these points Dr. Smith particularly directs attention. Regarding the conditions of many springs, which never become muddy, but possess a constant brilliancy and a very equal temperature all seasons of the year, the author thinks that there is a purifying and cooling action going on beneath. The surface water from the same place, even if filtered, has not the same brilliancy; it has not the same freedom from organic matter, neither is it equally charged with carbonic acid or oxygen gas,—there are other influences therefore at work. The rain which falls has not the purity, although it comes directly from the clouds; it may even be wanting in cleanness, as is often the case. Springs rise through a great extent of soil, and collect a considerable amount of inorganic salts; and it is shown by Dr. Smith that their purity is due entirely to the power of the soil to separate all organic matter, and at the same time to compel the mixture of carbonic acid and oxygen. The amount of organic matter removed in this way is surprising, and it is a most important and valuable property of the soil. The change even takes place close to cesspools and sewers; at a very short distance from the most offensive organic matter there may be found water having little or none in it. As an agent for purifying towns, this oxidation of organic matter is the most extraordinary, and we find the soil of towns which have been inhabited for centuries still possessing this remarkable power. St. Paul's Churchyard may be looked upon as one of the oldest parts of London, and the water from the wells around it is remarkably pure, and the drainage of the soil is such that there is very little of any salts of nitric acid in it. If the soil, says Dr. Smith, has such a power to decompose by oxidation, we want to know how it gets so much of its oxygen. We must, however, look to the air as the only source, and see how it can come from it. When water becomes deprived of oxygen, it very soon takes it up again,—as may be proved by experiment. This shows us that as fast as the oxygen is consumed by the organic matter it receives a fresh portion, conveyed to it by the porous soil. Several experiments of the following character were given, to show the filtering power of the soil:—A solution of peaty matter was made in ammonia; the solution was very dark, so that some colour was perceived through a film of only the twentieth of an inch in thickness. This was filtered through sand, and came out perfectly clear and colourless. Organic matter dissolved in oil of vitrol was separated from it by a thickness of stratum of only 4 inches. A bottle of porter was by the same process deprived of nearly all its colour. The material of which this filter is made is of little importance. One of the best, according to Dr. Smith, as far as clearing the water is concerned, being of steel filings; oxide of iron, oxide of manganese, and powdered bricks, all answer equally well. This shows that the separation of the organic matter is due to some peculiar attraction of the surfaces of the porous mass presented to the fluid.

REGISTER HYGROMETER.

This instrument was invented by Mr. Appold, for the purpose of keeping the atmosphere of his house, in Finsbury-square, at one regular degree of moisture. It is made so that a variation of one-quarter of a degree in the hygrometric state of the atmosphere will open a valve capable of supplying ten quarts of water per hour, and convey it on to the surface of warm pipes covered with blotting paper, by which the water is evaporated until the atmosphere is sufficiently saturated, and the valve thereby closed. A lead pencil *x*, attached, registers the distance the hygrometer

travels, and thus a sheet of paper moved by a clock would show the hygrometric state of the atmosphere at any period of time. The instrument is made with two bulbs, *a* and *b*, of a cylindrical shape, 7 inch diameter and 1½ inch long, placed vertically, so that the surface of the mercury may always be the same size; the bulbs are about 9 inches apart, with mercury enough in them to fill one, and connected together by a glass tube, that the mercury may flow freely from one to the other. A little ether is placed in each bulb, and the remaining space filled with the vapour from the ether. The bulbs are fixed upon a balance, so that when one bulb becomes warmer than the other, the ether forms vapour in one, and condenses in the other, by which means the mercury is driven from one bulb to the other.



It will be observed that the wet bulb *b*, is placed under the fulcrum, for the purpose of keeping it always in contact with the water; the other end *a*, is held up by a spring *e*, connecting the two horizontal levers *d*, and *c*, so that it can be adjusted to agree exactly with the action of the mercury; this is done with both bulbs dry, and made to stand in any position, the spring counteracting the weight of the mercury. When in use, the spring and levers are lowered, allowing as much mercury to flow into the dry bulb *a* as may be required; the drier the atmosphere is required to be, the lower the dry bulb must be placed. The valve *f*, is fixed to one end of the top lever *d*, that the lever *c*, which opens the valve, may be always in the same situation relative to the hygrometer. In the place to which it belongs the water is laid on with a gutta-percha pipe. The brass vessel at top serves for a temporary cistern, to show the action of the valve. *u*, weight attached to the lower lever *c*; *z*, set screw for upper lever; *m*, cistern that receives the water from the valve, the overflow of which goes on to the pipes; *n*, overflow pipe.

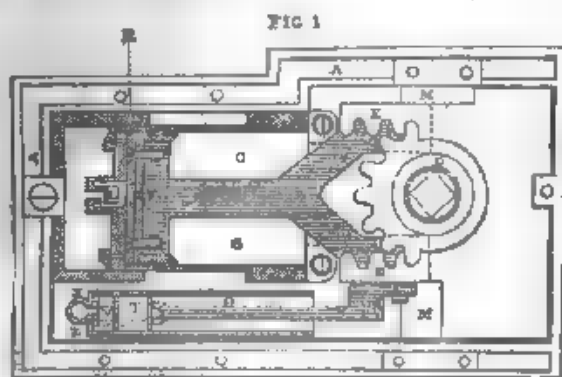
DOOR SPRING HINGE.

An improved Door Spring. Invented and patented by GEORGE BEATTIE, builder, Edinburgh.

In all steel springs there is a defect in the want of uniformity of pressure throughout the travel of the door, which usually increases as the door is opened wider, and makes it disagreeable to the person opening it; and when it closes, a rapid slam takes place; and if the door has glass in it, it is liable to be broken. By the improved hinge these defects are avoided, and there is no metal spring of any kind used, the motive power being obtained by the pressure of the atmosphere (which is well known to exert a pressure of 15 lb. to the square inch) acting on one side of a piston; the other side being a vacuum. In applying this pressure to shut a door, about 2 lb. to the square inch is lost by the friction of the machinery. The pressure of the air acts simply as a counter-balance on the piston, the resistance being uniform throughout the travel of the door when opening it, and when shutting the door

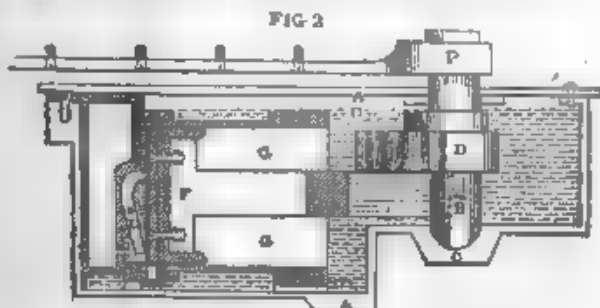
the regularity of motion and avoiding of slam is obtained by means of a stream of oil being made to discharge from a cylinder through a large or small aperture, according to the speed required. Fluids being almost incompressible, the oil will not pass through the apertures beyond a given rate, which is in proportion to the size of the aperture and the quantity to be discharged, and the power of the cylinder the vacuum is formed in to press it through. There is nothing in the machinery employed liable to break or get out of order.

The air-spring consists of an iron box and cover *a*, let into the floor, which contains a vertical axle *n*, supported at bottom in a hollow cup *o*, and furnished at the top end which projects above the floor with a shoulder and lever hinge *p*, for carrying the door on this axle; and within the box is fastened a horizontal wheel *q*, which is toothed upon a portion of its circumference. On each side of this wheel is a rack *r*, attached to a piston *v*, which is made to fit tightly into a cylinder *u*, by a cap leather *m*. In the under side of the cylinder is a valve *x*, communicating with the outside; in the bottom of the cylinder is another valve *z*, communicating with an exhausted chamber. On each side of the racks are guides *s*, for the piston.



PLAN.

The teeth of the wheel are made to take in either of the toothed racks as the door or gate is opened one way or other, so that the piston will be drawn along the cylinder, leaving a vacuum behind at a uniform and regular degree of resistance until the door is released, when the unbalanced pressure of air upon the face of the piston will cause the door to resume its original position.

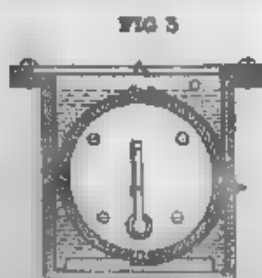


VERTICAL SECTION.

The use of the valve *x*, communicating with the outside of the cylinder is that, in case of a leakage of air behind the piston, it shall be driven by the return of the piston through it to the outside.

The use of the exhausted chamber and valve *z*, communicating with it is, that a small portion of the leakage air or oil which cannot be discharged through the valve *x*, leading outwards, escapes into the exhausted chamber, which allows the piston to get to the bottom, and to bring the teeth of the rack in hard contact with the teeth of the wheel, and thereby keep the door in its proper place when shut; in fact, gives it a maintaining power.

The regulator is for tempering the speed of the door when shutting. It consists of a small cylinder *q*, with a piston *r*, made to fit tightly into it by hemp packing; in the



VERTICAL TRANSVERSE SECTION

piston *r*, is a conical valve *v*, opening inwards to charge the cylinder with oil when opening the door. This valve closes when the door begins to shut. At the end of the cylinder *q*, is another valve, or what is commonly called a cock, which regulates the discharge of the oil which passed into the cylinder during the opening of the door. According to the size of the aperture *x*, in the cock, so is the time it takes to discharge the oil, and so is the speed of the door in resuming its position when shut, which completely prevents the motion increasing beyond what is wanted, and avoids slamming.

The box requires to be filled with lard or sperm oil up to the dotted line *o*, to seal the piston and keep the whole lubricated.

These hinges have been used for some of the public establishments in Edinburgh with success.

ELASTICITY OF CAST-IRON.

The Hyperbolic Law of Elasticity of Cast-Iron. By HENRY COX, B.A. Jesus College, Cambridge.

The object of this paper was to show that the extension and corresponding tensile force of a cast-iron rod are related to each other nearly as the ordinates of a hyperbola. That the tension and extension are not directly proportional, but that there exists what is termed a *defect of elasticity* was shown by Leibnitz, James Bernoulli, and others.

The real law of elasticity of any material can be ascertained only by direct experiments, and differs slightly even for two different specimens of the same material. All, therefore, that can be done in expressing the law by a formula is to represent the average of several experiments. The results of a set of experiments can be represented with any required degree of accuracy by a formula expressing the weight by ascending integral powers of the corresponding extension. The ordinary law stops at the first term of the series; and the modification which most readily suggests itself is to extend the series to the second term; so that if *e* be the longitudinal extension of a uniform rod, *w* the weight producing it, and *A* and *B* empirical constants,

$$w = Ae - Be^2 \dots\dots\dots (1)$$

From the experiments recorded in the Report (1849) of the Commission "appointed to inquire into the application of Iron to Railway Structures," it is manifest that the formula (1) adopted in the Report is subject to unavoidable inaccuracies. Eight formulae are given for extension of different kinds of iron; and it is observable in each case, without exception, that at least one-half, and generally more, of all the results of each set come together in the middle of the series with the errors in excess, and are preceded and followed by results in which the errors are in defect. The general character of the errors is therefore this—they are at first negative, then positive, and increasing in magnitude up to some term near the middle of the series. They then decrease till they become negative again. It may be shown by simple algebraical reasoning that the error may be nearly expressed by the first, second, and third powers of the weight; and this expression, added to the original formula, gives a *cubic* formula which is more correct than either the quadratic or bi-quadratic formula as obtained in the Report.

All these formulae lead to very complicated results in their mathematical applications. That, however, which is here proposed, possesses the advantage of far greater simplicity combined with accuracy greatly exceeding that of the quadratic formula.

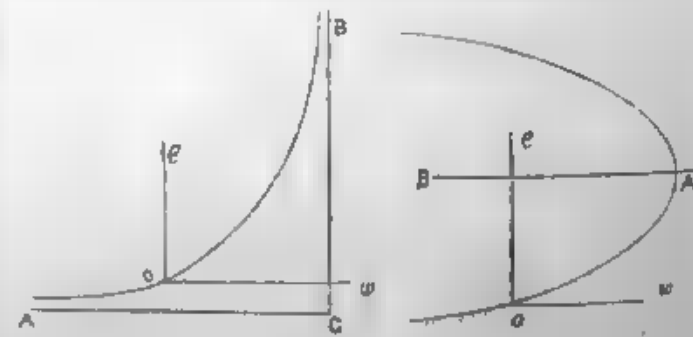


Fig. 1.

Fig. 2.

If *e* be the extension of a rod produced by a stretching weight *w*, it will be found by examination of the experiments that the

relation between e and w may be closely expressed as follows:—

$$w = \frac{\alpha e}{1 + \beta e}; \quad \text{or, } e = \frac{w}{\alpha - \beta w};$$

which is the equation to a rectangular hyperbola of which e and w are the co-ordinates. Let (fig. 1) CA, CB, be the asymptotes; then referring to the above equation, e and w will be measured along the axes oe , ow , respectively, o being the origin.

Similarly, the formula $w = Ae - Be^2$ is the equation to the parabola (fig. 2); oe , ow , are the axes of e and w ; AB the axis of the curve, and A its vertex.

The formula now proposed may be therefore considered to exhibit the HYPERBOLIC LAW OF ELASTICITY, and the last-mentioned formula the PARABOLIC LAW, in consistency with the nomenclature adopted by James Bernoulli in the 'Acta Eruditorum' of Leipzig, 1694. In the tables accompanying this paper, comparison is made between the two formula for cases of extension and deflection; the accuracy of the former is shown to be always the greatest—the error of the parabolic formula being, on the average, between three and four times as great as that of the hyperbolic formula.

Assuming, then, the proposed expression for the extension of a rod of a unit of length and a unit of sectional area, and the analogous one for compression (d), by a weight (w),

$$w = \frac{\gamma d}{1 + \delta d}$$

It is found that the deflection f , of a rectangular beam of length $2a$, of depth $2d$, in the direction of deflection, and width b , by a force $2P$, applied perpendicularly at the centre of the beam, is

$$f = Pa^3 \div \left\{ \mu d^3 (a + \gamma) - \frac{27}{16} Pa^2 \frac{a\delta + \gamma\delta}{a + \gamma} \right\},$$

which is the hyperbolic formula for deflection.

Hence, an expression is deduced for the ultimate deflection of rectangular beams, from which it follows that their strength is as their thickness and the cube of their depth directly, and as the length inversely—the law usually adopted in practice hitherto. It is true that this law was not formed to be followed exactly in the experiments above referred to, where the magnitude of the beams differed greatly; but the irregularity is explained in the Report as due principally to the superior hardness of small castings.

Lastly, by substituting in the above formula for the deflection numerical values of f , a and δ , obtained from the experiments on extension, the numerical co-efficients are obtained in the formula for compression. This method seems to tend to more correct results than the experiments on direct compression, detailed in the Report. For those results are extremely irregular, and were vitiated by the inclosure of the compressed rod in rectangular tubes, the sides of which were pressed by the rods when they became bent; and this pressure had great effect to resist the compressing force at the end of each rod. The numerical values of the co-efficients of compression in the hyperbolic formula agree closely together when computed, by the above-mentioned method, from experiments on deflection of different bars.

The great desideratum for the improvement of the hyperbolic or any hypothetical law of elasticity is a knowledge of the manner in which the strength of cast metal is influenced by the magnitude of the casting; and it is to be hoped that this defect of practical knowledge will not long remain unsupplied.

VALUE OF WASTE GASES FROM BLAST FURNACES.

On the Value of the Gaseous Escape from the Blast Furnaces at the Ystulfra Iron-works, in Wales. By Mr. PALMER BUDD.

Mr. Budd stated that, since the meeting of the Association at Swansea, he had continued, and with increased success, to apply the waste gases that escaped from the top of blast furnaces, to the manufacture of iron; and it was the result of his farther experience applied to the whole of his furnaces (nine in number) since that period, that he now wished to submit to the Section. He considered that he could not have fallen on a better locality for this purpose than Scotland, where the iron trade has been developed with a rapidity that is quite surprising, and quite characteristic of the enterprise of Scotchmen. Twenty-five years ago, Scotland was of no importance in the iron trade, but since then the produce of iron in Scotland had increased to between six and seven hundred thousand tons a-year. In that short period Scotland had accomplished a production which Staffordshire and other places in England took two hundred years, and South Wales a hundred

years to accomplish—the make of iron in Scotland being now equal to that of either England or Wales. This great accession to the produce of iron has had a sensible effect on its price; but as he believed that necessity was the mother of invention, and that nature had in store for us an immense reservoir of riches to be yet developed, he was of opinion that the tendency of all this cheapness was to teach us that nothing should be wasted, and that we should look forward to the time when the smoke that at present contaminated the atmosphere, and the filth that polluted our streets, would be regarded as too valuable to be wasted.

When we considered the utility of iron, its low price, and its general distribution in the deposits of every age, we could not but look upon it otherwise than as the great agent in modern civilization.

Mr. Budd then referred to his mode of applying the gaseous escape, and said it was well known that there were two descriptions of furnaces used for metallurgic purposes. The one was the blast furnace, into which air was injected, by mechanical means, at a great density, so as to penetrate upwards of forty feet of dense materials; and the other the reverberatory furnace, where the fire was produced by means of the draught of a chimney stack. What he had accomplished was by combining these two, so that the gaseous products of the furnace, instead of escaping through the funnel-head, were drawn sideways by a high stack, and passing through the stoves and boilers, leave behind the necessary temperature of the blast and of the steam. In a blast furnace the ores are smelted before the *tuyeres* by the conversion of the solid carbon into carbonic acid, which, passing up through the middle region of the furnace into a bath of carbon, was reconverted into carbonic oxide, capable of combining with a farther dose of oxygen. It would be thus seen that the whole of the carbon of the fuel should be present at the top of the furnace in a gaseous form. When the British Association met at Swansea, he had not used the gaseous escape at any great distance from the furnace, his stoves and boilers being very closely contiguous. Further experience, however, had proved that by the aid of a stack at the end of the chain of sufficient dimensions, the gaseous escape from the furnace might be made to travel in the most tortuous directions, descending to the stoves built for heating by the usual fire-places, and traversing the boilers; the only condition absolutely necessary being that there should be an unbroken communication with the high stack at the end, into which the gaseous escape might at last pass, and by which it was drawn forward, instead of passing off wastefully at the funnel-head. When, however, the draught was carried downward, and to long distances, he had found it necessary to drop into the top of the furnace a hopper or funnel, made of sheet-iron, which acted as a shield at the mouth of the horizontal flues, and prevented them from either being affected by high winds, or from being choked up by the materials thrown into the furnace.

The reason, no doubt, why this funnel was not applied before was the great apparent temperature at the funnel-head. In practice, however, it was found that until the gaseous escape mingled with the atmosphere, its heating power was not such as to injure sheet-iron, or even to make it red hot. In fact, so long as there was an escape upwards, the iron funnel would not be injured. The damage arose during and after stoppages of the furnace, when the blast was obstructed in its passage upwards by the settlement of the materials in the furnace, so that the atmosphere rushed down to meet the ascending gases, and of course, caused a very high local temperature. His practice was to exclude the atmospheric air as much as possible. The affinity of the gases for oxygen was so great that the air leakage raised the temperature quite sufficient for safety, whilst the full combustion of the gaseous escape would melt down the bricks in the flues, and destroy the texture of the iron tube. It was not possible for him to say what combinations took place at high temperature, where carbonic oxide, carbonic acid, hydrogen, and nitrogen, were mixed in such proportions. At any rate, he found a smothered combustion to be the most suitable and economical for the purposes in view.

He was happy to say that, at length, the application of the gaseous escape had been tried in Scotland; and that at Dundee and elsewhere it was now in successful operation. The peculiar quality of the furnace coal of Scotland being what was called in South Wales "free burning," which, when put into the furnace raw, coked sufficiently in its descent, gave out an enormous escape, so much so that, upon a rough estimate, he calculated that the waste from one furnace in Scotland was sufficient to heat the blast, and to raise the steam for three. With anthracite coal, the minimum effect was obtained, as it was a dense fuel of nearly 95 per cent. of solid carbon; but in Scotland there would be an enormous surplus at the funnel-head.

He expected, from the well-known sagacity of the Scottish people, that when truly embarked in this mode of operation the greatest possible use would be made of it; and he would not be surprised to see heat let out, like mill-power, for burning bricks and other similar purposes. He felt, however, anxious that the application should be made under the superintendence of competent parties, as he had known several instances where the plan had been abandoned from difficulties that might easily have been surmounted under proper directions. He was quite aware that, by the plan he had pursued, the utmost heat was not extracted from the gases; and that, by different means, a temperature might be obtained capable of performing all the operations of the forge; and if it be true that the solid carbon of the furnace in its escape, as carbonic oxide, would unite with another dose of oxygen for saturation, there could be little doubt that, with properly constituted gas furnaces, there was enough at present passing off to convert the pig iron into bar iron. He hoped some of the iron-masters of Scotland would follow up this hint effectually with regard to the remaining processes required for making malleable iron. He observed that the saving at the Dundyvan Iron-works was stated to be about $1\frac{1}{2}$ ton of coal for each ton of iron produced. Supposing, therefore, 600,000 tons of iron to be the produce of Scotland, and supposing the value of the coal used to be 3s. a ton, the saving that would thus be effected on the make of Scotland would amount to 112,500*l.* a-year; to which might be added 20,000*l.* a-year of saving in wages and repairs, which would make a total saving of 132,500*l.*, or about 4s. 6d. a ton on the produce of Scotland, which on the present price of 41s. per ton, was about 10 per cent. on the value. If the gaseous escape could be extended to the uses of the forge, a farther saving of three tons of coal would be effected—thus making, at least, a saving of 20s. a ton on all the iron manufactured into bars, sheets, and rails.

ELECTRICITY AND HEAT AS MOVING POWERS.

On the Application of Electricity and Heat as Moving Powers. By Mr. PETRIE.

From the dynamic equivalent of electricity, we can infer an important fact that one-horse power is the theoretic or absolute dynamic force possessed by a current of electricity derived from the consumption of 1.68 lb. of zinc per hour in a Daniell's battery. But the best electro-magnetic engine that we can hope to see constructed cannot be expected to give more than half or a fourth of this power; in any case we see here the limit of power which no perfection of apparatus can make it exceed. The peculiar mode in which the electric current produces dynamic effects has led to much miscalculation respecting the power obtainable from it. In any sort of electric engine the material to which the neighbouring current gives motion, whether it be another moveable current, or, what is more usual, a magnetic body, is impelled in one direction with a constant force, and this force, whether it be attraction, repulsion, or deflection, is, like the powers of gravity, sensibly constant at all velocities, however fast the body recedes before the action of the force, provided only the same quantity (per minute) of electric current be maintained. This is quite different from the action of steam power, in which the faster the piston moves the greater is the volume of steam per minute that must be supplied to move it, or else the less will be the power with which it moves. —This fact, then, that the force with which an electric current of a given quantity moves the machine, is the same at any velocity of motion, bears no analogy to the case of steam, but would indicate that the dynamic result obtainable from a given electric current might be infinitely great; and so it would be, were it not that the part moved always tends to induce a current in the wire in the reversed direction, and this inducing influence, which increases with the velocity of motion, conflicts with the original current and reduces its quantity, and consequently reduces the power of the motion, as well as the consumption of materials in the battery. Some have imagined that possible alterations in the position of the parts of the machine, or in its mode of action, would avoid the evil, or even might make the induced current to flow with the primary current instead of against it; the impossibility of this, though not readily proved in detail, can be at once proved by reference to general principles. It would, if true, be a creation of dynamic force—the evolving an unlimited force from a limited source. The tendency to an opposing induced current in the primary wire must, therefore, be involved in the very principle of the system; so that no ingenuity can ever get rid of the retarding influence of the induced action; and the only way to overcome its power, so as

to maintain the primary current from falling below a given rate or quantity when the machine is allowed to attain rapid motion, is to increase the electro-motive power of the battery, the intensity (not the quantity) of the current, so that it should be less affected by the opposing induction.

The practical importance of these not altogether unknown truths, may justify the above somewhat particular notice of them. For want of a clearer apprehension of them, inventors have misapprehended the direction in which improvements were to be made and much ingenuity and means have been wasted.

Some of the best electro-magnetic engines of other inventors that have been properly tested by the author and others, on a practically useful scale, have only given a power at the rate of 50 to 80 pounds of zinc per horse-power per hour. The smallness of this power in comparison with the absolute value of the current (1.68 pound of zinc per horse-power per hour) should not occasion surprise if we consider the present case of steam after many years of improvement.

According to the determinations of Youll and of Rankine on heat, one pound of water raised one degree of temperature, is equivalent to 700 lb. weight raised one foot. The author then proceeded to show that the best Cornish engines only yield $\frac{1}{4}$ th of the power that the combustion of the carbon actually represents, and many locomotives only $\frac{1}{16}$ th part;—showing what great rewards may yet await the exercise of inventive genius in this department, and that we need not wonder that we have, as yet, only obtained $\frac{1}{16}$ th part of the power possessed by electricity. But it is to be remembered that there is a far greater likelihood of obtaining a larger proportion of the real power from electricity than from heat, owing to the character of the two agents.

Mr. Petrie then proceeded to explain the reasons why so little of the power of heat could be obtained in a useful form, even in the best steam-engines, and what were the difficulties for invention first to overcome in order to a better result.

In the case of electricity, however, there is no analogous difficulty; but we have instead the difficulty and expense of developing current electricity by the chemical actions now requisite. If carbon could be burnt or oxidised by the air, directly or indirectly, so as to produce electricity instead of heat, one pound of it would go as far as $2\frac{1}{2}$ pounds of zinc (in a Daniell's battery) chiefly because there are as many atoms in one pound of carbon as there are in $2\frac{1}{2}$ pounds of zinc, and partly because the affinity (for oxygen) of each atom of (incandescent) carbon is greater than that of an atom of cold zinc, minus the affinity of the hydrogen for the oxygen in the water of the battery. Apart, however, from such prospects of improved means of obtaining electricity, its favourable feature, on the other hand, in comparison with heat, is, the reasonable expectation that we may obtain from electricity a considerable portion of the power which Mr. Petrie has determined as being the dynamic equivalent of the electric current.

REVOLVING LIGHTHOUSE LIGHTS.

On the Limits to the Velocity of Revolving Lighthouse Apparatus caused by the time required for the production of Luminous Impressions on the Eye. By WILLIAM SWAN, F.R.S.E.

The object of this communication is to ascertain the greatest velocity that can be given to a revolving lighthouse apparatus, without impairing the brightness of the light. It is well known that at a given distance the apparent brightness of a revolving light exceeds that of a fixed one, supposing the intensity of the source of illumination to be the same in both cases; and this effect is due to the fact that the revolving apparatus collects all the light into beams of nearly parallel rays, which illuminate only a small portion of the horizon at any instant, while the fixed apparatus scatters its rays over every point in the horizon. The question might occur, is it possible to continue the superior intensity of the revolving with the constancy of a fixed light by increasing the velocity with which the apparatus revolves so as to cause its flashes to reach the eye in rapid succession? The attempt to combine in this manner the advantages of the two systems of lights was actually made by the late Captain Basil Hall, who, founding on the well known phenomenon of the persistence of impressions on the retina, conceived the ingenious idea of causing a revolving light to rotate so rapidly as to produce a continuous impression on the eye.

The practical efficiency of this arrangement was tested by Mr. Alan Stevenson; and the result of his experiments is described in

his recent work on the Skerryvore Lighthouse.* An octagonal frame, carrying eight lenses, was made to revolve with various degrees of rapidity, and the light was observed at a distance of 14 miles. It was then found, that as the rate of revolution was accelerated, the apparent brightness and volume of the flashes diminished; until when a velocity of eight or ten flashes in a second was obtained—the light became almost invisible. Mr. Stevenson correctly explains this result by supposing, that when the lenses revolved rapidly the light had not sufficient time to produce its full effect on the eye. While these experiments sufficiently prove the impossibility of obtaining the result Captain Hall had in contemplation, yet in the absence of definite information regarding the connection which subsists between the apparent brightness of an object, and the time during which its light has acted on the eye, it is obviously impossible, without actual trial, to assign the limit to the velocity of a revolving light. This information is supplied by the author's researches on the time required for the production of luminous impressions on the eye, published in the 'Transactions of the Royal Society of Edinburgh' for 1849. His experiments were conducted by means of an apparatus, consisting of two screens, each with circular apertures an inch in diameter, to which are fitted pieces of ground glass. The apertures are illuminated by gas burners, which admit of having their distances from the screens varied at pleasure, by sliding their supports along the plank in a groove cut in it for that purpose. The brightness of the apertures in the screens is observed by means of a rectangular prism of glass placed half-way between them, with its faces inclined at angles of 45° to the line joining their centres. By this means the apertures are seen in apparent contact, and their relative brightness can thus be compared with great nicety. A disc is made to revolve on the axis in front of one of the screens, having a sector of a known angle cut in its circumference; and in this manner the aperture is seen for a short interval of time at each revolution of the disc. The time during which the light acts on the eye is easily ascertained, by knowing the velocity of the disc, and the ratio the arc of the sector bears to its whole circumference.

Before causing the disc to revolve, the apertures in the screens are made equally bright by varying the distance of the light from the screen. When the disc is then made to revolve, the apparent brightness of the aperture behind it is instantly diminished; and the equality of the brightness of the apertures in the screens is restored by increasing the distance of the light from the screen. The ratio of the brightness of the impression produced by the light during the revolution of the disc to the brightness of the impression when seen by uninterrupted vision, is that of the squares of the distances of the light from the aperture before and during the revolution of the disc. By means of this apparatus, it was found.—1. That when light of a given intensity acts upon the eye for a short space of time, the brightness of the luminous impression on the retina is sensibly proportioned to the time during which the light continues to act. Thus, the intensity of an impression made in .01 seconds is almost exactly $\frac{1}{100}$ th of the brightness of the light when seen by uninterrupted vision; and the intensity of the impression is exactly doubled in .02 seconds.—2. Lights of every degree of intensity produce their impression on the eye with equal rapidity.—3. The time required to produce a complete impression is about one-tenth of a second.

The conclusion to be drawn from these experiments seems to be, that in any proposed revolving light, the velocity of rotation ought to be regulated so that the duration of each flash must at the very least exceed $\frac{1}{10}$ th of a second. This velocity can be easily calculated, for the arc of the horizon, included by the brightest portion of the flash, is equal to the minimum divergence of the rays; and this, again, is equal to the angle which the horizontal diameter of the flame subtends at the edge of the aperture of the lens or reflector,†

If, then, t = the time of a complete revolution, t' = the duration of the flash, and a = the divergence of the rays, $t = \frac{360}{a} t'$

Or, if we take $t' = \frac{1}{10}$ th of a second as the shortest allowable duration of the flash, we shall have $at = 72$. Thus, in the case of the lens of Fresnel's revolving light of the first order, the minimum divergence is 4" 44'; and the greatest velocity of rotation that could be employed without necessarily diminishing the apparent brightness of the flashes would be 7.6, or nearly 8 seconds.

In like manner the greatest admissible velocity for a parabolic reflector, whose focal length is 4 inches, and its greatest double

ordinate 21 inches, illuminated by a flame one inch in diameter, is one revolution in nearly 7 seconds.

In stating these cases, it is not of course assumed that so great velocities would be found suitable in practice. All that can be inferred from the experiments with certainty is this, that any proposed arrangement which should employ Fresnel's great lens with a velocity exceeding one revolution in 8 seconds, would necessarily be disadvantageous; or more generally, that in every light-house arrangement, care must be taken that the flashes of light have time to act on the eye for more than one-tenth of a second.

COOLING THE ATMOSPHERE OF ROOMS IN TROPICAL CLIMATES.

On a Method of Cooling the Atmosphere of Rooms in a Tropical Climate. By Professor C. PIAZZI SMYTH, of the Edinburgh Observatory.

THE difficulty of effecting this object is so great, even in cooler countries, that while the apartment of a sick patient during winter is preserved carefully and easily, by means of a fire, at any desired temperature, if this be much exceeded during a few days in summer by the atmosphere, although the patient may visibly suffer from the heat, still the case seems to be thought so hopeless that the physician and friends are generally content merely to lament the untoward warmth of the weather; or, perhaps, in a few cases, to try to counteract some of the minor consequences of that prejudicial cause.

If the problem now proposed is to be solved in all its entirety, it must be stated thus:—

In a country where the thermometer stands at or above 90° Fahrenheit all through the 24 hours, both summer and winter, and where there can be no coolness in springs, wells, rivers, or the night air; and where the atmosphere is saturated with moisture, so that no cold can be produced by evaporation,—to lower the temperature of the air in rooms; to keep up a constant supply of pure cold air; and to remove that which has been warmed or otherwise vitiated.

To meet such a case, the present Indian methods are utterly inadequate, for the punkah, in its various forms, merely serves to agitate the air, and does not cool or purify it in the slightest degree. The wet mats which in some places are hung before windows, and being blown through, naturally or artificially, cool the transmitted air, would be inapplicable in the case now before us, where the air is saturated with moisture. And even where they can be employed, their use is objectionable on the ground of their adding so much moisture to air already overloaded with it; for it cannot be too strongly borne in mind, that in warm countries, though the air may often feel dry to the human frame, that still, on account of the air's capacity for moisture increasing with the temperature, there may be a far larger amount of watery vapour present than even in a Scottish mist.

And these are all the methods which have yet been brought forward for the relief of suffering humanity; for the bane to be removed is the too high temperature of the food of the lungs and the skin. The use of cold meats and iced drinks for the stomach must be regarded as a forlorn hope, and a mistaken idea.

A complete remedy would, however, seem to be presented in the property of air to increase in temperature on compression, and diminish on expansion—a fact strangely overlooked for this purpose, seeing how often workmen are stumbling upon it, while every book on Hydraulics contains an account of the Schemnitz machine, where air rushing out from great compression freezes the drops of water that issue with it; and every work on Natural Philosophy describes the syringes in which, by the sudden compression of air, tinder is ignited.

When cold air is to be produced in this way, it is evident that as the quantity of heat continually decreases for each succeeding atmosphere of pressure, it is desirable so to arrange the machine as to compress the greatest possible quantity of air the least degree necessary to produce the required temperature, than to obtain exceeding cold by compressing violently a small quantity of air, and diluting that afterwards with a larger quantity of common air.

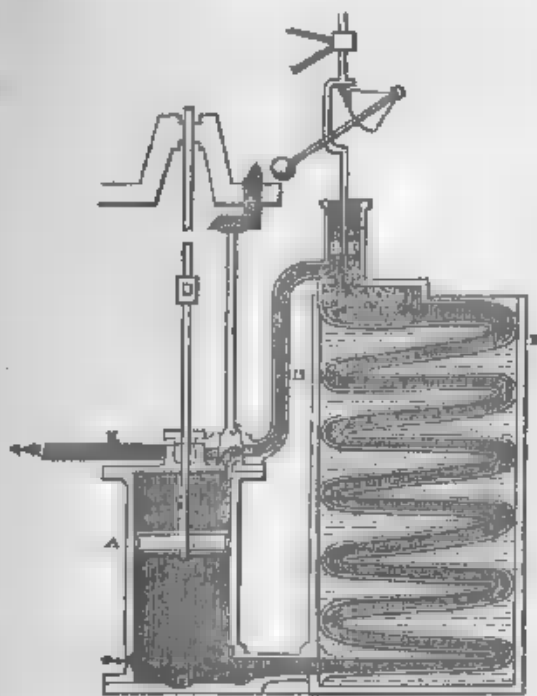
After some consideration,* a compression of one-fourth an at-

* If machinery could be executed perfectly, a high degree of compression might be effected, and the compressed and cooled air might be made to react in the expansion of the bulk of the piston which is compressing the air in front of it; thus saving all the power exerted but that lost in friction, diminished bulk of the cooled air, and imperfect expansion and leakage; but on submitting the matter to calculation, there did not seem to be any possibility of adopting the method with advantage in the present moderate degree of perfection of pneumatic engines.

* See Stevenson's 'Account of the Skerryvore Lighthouse,' p. 212.

† See Stevenson's 'Account of the Skerryvore Lighthouse,' p. 212, 257.

mosphere has been thought to be sufficient in most cases; and the following arrangement of the machinery has been adopted for a one-horse power, which may be expected to furnish a room with about 80 cubic feet of air per minute, cooled 15° to 20° below the atmosphere outside. A double-acting air-pump, 9 inch diameter, and 18 inch stroke, making 60 double strokes per minute, with a jacket of cold water round the cylinder to mitigate the heat of friction, forces the air into the lower end of a coil of copper tube, contained in a tub of water, 3 feet diameter and 3 feet high, where the cooling is effected. At the upper end of the tube is a safety valve, which permits an escape of the confined air, when it exceeds 7 lb. on the square inch, into a larger tube, which at once conducts the now cooled air into the desired apartments. Where the work is constant, the piston should have a metallic packing, and the usual contrivance in stills should be adopted for changing the water of the worm tub.



A, air-pump; B, still-worm tub; c, inlet air-valve; d, outlet valve for compressed air; e, worm-tub; f, chamber for compressed and cooled air; g, loaded valve to regulate compression; h, tube for expanded air; i, valve to regulate expansion; k, tube for conveying the expanded air to the room to be cooled.

The room to be filled with cold air should either be surrounded by a wall, unbroken by doors and windows, to at least 4 feet in height; or, which would be the better plan, should be sunk that, or a greater depth, in the ground. For the exit of the warm air, the opening of an upper wash of a window will be quite sufficient.

With regard to the power which is necessary to work the pump, a small steam-engine, though convenient as subserving a residual difficulty to be presently mentioned, would perhaps hardly be suitable but for a very few spots in India. A pair of bullocks would be the power most easily procurable in the greatest number of places, and at a very low rate. The manufacturer here should therefore send out with the pump a portable "horse-work," i.e. a small mill-work, such as horses or oxen might be applied to, and which by means of wheels and pinions or bands, should produce the necessary quickness of motion for the cranked axle of the pump. Where water-power is available, it should on no account be neglected; and in the majority of cases it is probable that the wind might be turned to good account.

So much for the sort of power by means of which the cooling apparatus is to be worked. But this being supposed to answer, a residual difficulty may be expected to arise in many cases—the cooled air will be found unpleasantly moist. This may be corrected by the natural tendency of air to deposit its moisture on metallic bodies colder than itself; and by making the tube which conveys the cooled air into the room pass through a still colder vessel of water, the moisture will be condensed on the inside surface of the metal, and may be conducted away by a subsidiary pipe. Where mechanical power is cheap, this vessel of water may be kept at the low temperature by passing through it air which has been

compressed to a still greater degree than that conveyed through the tubes to the rooms; or where fuel is cheap, by the liquefaction of salts. Of this kind, a great number of freezing mixtures have lately been produced, and the exact constituents have been kept secret by the manufacturers; but it is probable that no more convenient combination can be employed than saltpetre and sul-ammoniac, both easily procurable in India; and, having the unusual property amongst salts of crystallising separately from the combined solution, they may be used over and over again *ad infinitum*, employing a fire if natural means are insufficient for evaporating the fluid.

We thus see that there is a natural law which we may avail ourselves of, to cool air to any extent by the employment of mechanical power; and simply in compressing air by means of a forcing pump into a closed vessel, which is a good conductor of heat, as a coil of pipe under water; the air will rise in temperature at first to a degree proportioned to the compression, say 50° Fahrenheit above whatever it was before; so that whether the atmosphere we begin operations in is 70° , or 100° , or 120° Fahrenheit in the shade, it matters not to the success of this method. The compressed air, which would thus have risen in the intermediate case from 100° to 150° , would by degrees give off that extra heat to the water surrounding the cooler (it is only necessary, it will be observed, to have a certain quantity of water of a temperature not above 100° , which in general will not be very difficult to obtain); and if the air then be allowed to escape from the pressure and confinement into the atmosphere, it will fall again 50° below 100° , or be found at 50° Fahrenheit.

If the air had been allowed to escape immediately after compression, its temperature would not have been altered in the final result, it would have been increased certainly on compression to 150° ; but then expanding from there, the cooling effect could only bring it down to 100° . If, however, as described above, we carry off the extra 50° by conduction and radiation during the time of the air being in the compressed state, then it evidently must issue at the low temperature of 50° Fahrenheit; and if a sufficiently large pump is kept at work, and the cooler of the compressed air be sufficiently extensive, there is evidently no question but that of expense to prevent us from having a constant stream of any amount of air issuing from the other end of the apparatus, and cooled to any extent that may be desirable.

This I believe is the first time that this property of air has been put into requisition for any purpose of the sort, but it first occurred to me in South Africa in 1843. In 1844 I had a small apparatus made to test this matter experimentally at the Cape, and a larger one in Edinburgh in 1847; and in this way ascertained that the quantity of rise in the temperature of air for a small degree of compression was so great (about 30° Fahrenheit for $\frac{1}{2}$ of an atmosphere), that there could be no doubt that when a good arrangement of the machinery had been planned, and when it had begun to be manufactured on a large scale, it would be found to be abundantly within the means of most of our countrymen in India and in tropical climates.

Thus I hope that the general problem of cooling the air of rooms in tropical climates, may be considered to have been completely solved, and that by no very expensive means or complicated apparatus. And should the Society be of the same opinion, and private gentlemen be disinclined to run the risk of incurring expense for a machine which has never yet been practically tried, then I do hope that some steps may be taken to urge on the honourable East India Company or her Majesty's government, the propriety of trying the experiment in some of the large hospitals, where the plan could be so much more efficiently carried out and superintended than in a private establishment, and where so many of our countrymen may be suffering, and even dying, at this moment sheerly from the effects of too much warmth in the atmosphere.

ATLANTIC WAVES.

On Atlantic Waves, their Magnitude, Velocity, and Phenomena. By Dr. SCURRY.

DURING two passages across the Atlantic in 1847-8, I had opportunities for investigating certain elements respecting deep sea waves more favourable than had ever before occurred within my experience in navigation. These observations, it should be noted in the outset, and the results deduced from them, were entirely uninfluenced by, and separate from theory. They form but a contribution to this interesting branch of natural phenomena; but I offer them the more readily from the circumstance of their entire

independency and speciality. It was in our return voyage from America that the highest seas occurred, when the circumstances adapted for interesting observations were singularly favourable; for, whilst the magnitude and the peculiar construction of the upper works of the ship—the *Hibernia*—afforded various platforms of determinate elevation above the line of flotation for observations on the height of the waves, the direction of the ship's course, with respect to that of waves, was generally so nearly similar as to yield the most advantageous agreement or accordance for observations on their width and velocity. These observations I shall extract, in their order, from my journal kept during the homeward passage.

My first observation worth recording is under the date of March 5, 1848, when the ship was in latitude about 51° , and longitude (at noon) $38^{\circ} 30'$ W.—the wind then being about W.S.W., and the ship's course, true, N. 52° E. At sunset of the 4th the wind blew a *hard gale*, which, with heavy squalls, had continued during the night; so that all sail was taken in but storm-staysail forward. The barometer stood at 29.50 at 8 p.m., but fell so rapidly as to be at 28.30 by 10 the next morning. In the afternoon of this day I stood some time on the saloon deck or cuddy roof—a height, with the addition of that of the eye, of 23 feet 3 inches above the line of flotation of the ship,—watching the sublime spectacle presented by the turbulent waters. I am not aware that I ever saw the sea more terribly magnificent. I was anxious to ascertain the height of these mighty waves; but found almost every wave rising so much above the level of the eye, as indicated by the intercepting of the horizon of the sea in the direction in which they approached us, as to yield only the minimum elevation, and to show that the great majority of these rolling masses of water possessed a height of considerably more than 24 feet (including depression as well as altitude), or, reckoning from the mean level of the sea, of more than 12 feet. Exposed as the situation was, I then ventured to the larboard paddle-box, which was about 7 feet higher, where the level (as ascertained afterwards at Liverpool, allowance being made for the alteration in the draught of water of the ship,) was 24 feet 9 inches above the sea. This position, with 5 feet 6 inches, the height of my eye, gave an elevation altogether of 30 feet 3 inches for the level of the view then obtained,—a level, it should be remarked, which was very satisfactorily maintained during the instants of observation, because of the whole of the ship's length being occupied within the clear "trough of the sea," and in an even and upright position, whilst the nearest approaching wave had its maximum altitude. Here, also, I found at least *one-half* of the waves which overtook and passed the ship were far above the level of my eye. Frequently I observed long *ranges* (not acuminate peaks) extending 100 yards, perhaps, on one or both sides of the ship,—the sea then coming nearly right aft,—which rose so high above the visible horizon, as to form an angle estimated at 2 to 3 degrees (say $2\frac{1}{2}^{\circ}$) when the distance of the wave summit was about 100 yards from the observer. This would add near 13 feet to the level of the eye. And this measure of elevation was by no means uncommon,—occurring, I should think, at least once in half-a-dozen waves. Sometimes peaks of crossing or crests of *breaking* seas would shoot upward at least 10 or 15 feet higher. The *average* wave was, I believe, fully equal to that of my sight on the paddle-box, or more, that is, $20 = 15$ feet, or upwards; and the *mean* *highest* waves, not including the broken crests, about 43 feet above the level of the hollow occupied at the moment by the ship. Illuminated as the general expanse not unfrequently was by the transient sunbeam breaking through the heavy masses of the storm-cloud, and contrasting its silvery light with the prevalent gloom, yielding a wild and partial glare, the mighty hills of waters rolling and foaming as they pursued us, whilst the gallant and buoyant ship—a charming "sea-bird"—rose abast as by intelligent anticipation of their attack, as she scudded along, so that their irresistible strength and fierce momentum were harmlessly spent beneath her and on her outward sides,—the storm, falling fiercely on the scanty and almost denuded spars and steam chimney raised aloft, still indicated its vast, but as to us innoxious, power, in deafening roarings, altogether presented as grand a storm-scene as I ever witnessed, and a magnificent example of "the works of the Lord," specially exhibited to sea-going men, "and his wonders in the deep." In the afternoon of the same day the gale again increased, blowing, especially during the continuance of a much protracted hail-shower, terrifically,—roaring like thunder whilst we scudded before it, causing the ship to vibrate as by a sympathetic tremor, and the tops of rolling waves too tardy, rapid as was their actual progress, for the speed of the assailing influence, to be carried off

and borne along on the aerial wings in a perfect drift of spray! But during the period of these most vehement operations of nature, I was fortunately enabled, from familiarity with sea enterprise, to pursue my observations with entire satisfaction.

The next day—March 6—added to the interest of these investigations by developing the character of the Atlantic waves under a long and fiercely-continued influence of a little varying wind. It had blown a heavy gale, violent in the showers, from the north-westward, from Saturday evening the 4th, to the evening of Sunday, from 26 to 30 hours; during the night, too, of Sunday, it had again blown hard (abating towards the morning of Monday), and making a total continuance of the storm, in its violence, of about 36 hours.* I renewed my observations on the waves at 10 a.m.—the storm having been then subdued for several hours, and the height of the waves having perceptibly subsided. Soon I observed, when standing on the saloon-deck, that ten waves, in one case, came in succession, which all rose above the apparent horizon,—consequently they must have been more than 23 feet, probably the average might be about 26 from ridge to hollow. At this period I also found that occasionally (that is, once in about four or five minutes), three or four waves in succession, as seen from the paddle-box, rose above the visible horizon—hence they must, like those of the preceding day, have been 30 feet waves. But one important difference should be noted—viz., that they were of no great extent on the ridge, presenting, though more than mere conical peaks, but a moderate elongation. Another subject of consideration and investigation, on this occasion, was the period of the regular waves overtaking the ship, and the determination, proximately, of the actual width or intervals, and their velocity.—1. The ship was then going nine knots only, the free action of the engines being greatly interfered with by the heavy sea running, and the lines of direction of the waves and the ship's course differed about $22\frac{1}{2}^{\circ}$ degrees, the sea being two points on the larboard quarter—in other words, the true course of the ship was east; the direction from whence the sea came was W.N.W.

2. The period of regular waves, in incidental series, overtaking the ship were observed as follows:—

Waves.	Min. Sec.	Mean.
21 occupied 5 30	16.5"
12 .. 3 25	15.4"
10 .. 2 50	17.0"
19 .. 4 40	16.5"
8 .. 2 15	17.4"
General average..... 16.3"		

3. The length of the ship was stated to be 220 feet. The time taken by a regular wave to pass from stern to stem appeared, on a mean of several observations, to be about six seconds. Hence $6'' : 220 \text{ feet} :: 16.5 \text{ feet} : 16.5 \text{ feet}$ (the width passed over in that time) : 16.5 feet to 605 feet (the width passed over betwixt crest and crest.) But this extent, by reason of the obliquity of the direction of the waves to the course of the ship, is found to be elongated about 45 feet, reducing the probable mean distance of the waves to 559 feet. Independently of this process, I had previously estimated the distance of the wave crests, ahead and astern when the ship was in the hollow, as I stood near the centre of the ship's length on the paddle-box, at 300 feet each way, by comparing the intervals betwixt my position and the place of the wave-crest, with the known length of the ship. This comparison frequently re-considered and repeated, subsequently yielded, in much accordance with the former, a total width in the line of the ship's course, of about 600 feet.

4. But the total distance betwixt the crests of waves, then reckoned at 550 feet, a distance passed by the wave in 16.5 seconds of time, by no means indicates, it is obvious, the real velocity of the wave, as the ship meanwhile was advancing nearly in the same direction at the rate of nine knots—that is, nine geographical miles, or $(6075.6 \text{ feet} \times 9 =) 54,680.4 \text{ feet per hour}$, or 15.2 feet per second. During the time, therefore, of a wave passing the ship = $16.5''$, the ship would have advanced on its course $16.5 \times 15.2 = 250.6 \text{ feet}$. Reducing this for the obliquity of two points we have 231.5 feet to be added to the former measure, 559 feet, which gives 790.5 feet for the actual distance traversed by the wave in 16.5 seconds of time, being at the rate of $(\frac{3600'' \times 790.5}{16.5} =) 17,231.7 \text{ feet}$, or 32.67 English statute miles per hour. To know how far this result is but proximate, it should

* The barometer on Saturday, at 8 p.m., was at 29.50; at 8 a.m. of Sunday it had fallen to 28.30, being 1.2 inches in 10 hours. At 8 p.m. of the latter day it had risen to 29.00 inches.

be considered that, of the several elements employed in the calculation, all but one might be deemed accurate.

The interval of time occupied by the transit of a wave with respect to the position of the ship, the direction of the ship's motion with relation to that of the waves, and the speed of the ship through the water, may all be recorded as essentially accurate. The element in doubt is that of the average distance from summit to summit of the waves. This distance, it has been seen, was by a twofold process of observation or comparison accordingly assumed. The value of the judgment derived from rapid comparison of measures by an eye accustomed to such estimations is, it should be observed, far higher than might be generally considered. The practical military commander or engineer officer is able to make, by mere inspection of the ground before him, remarkably close estimates of spaces and distances. When engaged in the Arctic whale fishery, I was enabled, from habit and comparison of unmeasured spaces with known magnitudes, to estimate certain distances with all but perfect accuracy. Thus, as to a circumstance in which we were most deeply interested—the near approach of a boat to a whale—I found it quite practicable, whenever the pursuing boat approached within twice or thrice its length (except when the position was near end on) to estimate the distance to less than a yard. Now, the means of comparison by the eye as to the estimation of the breadth of the Atlantic waves, was that of the ship's length of 220 feet. When the ship was fairly in the middle of the depression betwixt two waves it was assumed, with reference to this known measure, that something obviously less, but not greatly so, than the ship's length, was the distance of each of the two waves then contemplated—giving a total width of about 600 feet. But the comparison of the time required by a wave to pass from stem to stern, with the average time of transit of an entire wave, yielded a much better result; and, on much consideration of the subject, I am inclined to believe that the estimate is a tolerably close approximation to the truth. It should be observed, too, that as the headway of the ship, in the direction of the course of the wave—being a known quantity—it was favourable to the accuracy of the estimate. For, assuming an error in the width of the waves to have occurred, say to the amount of one-twelfth of the whole, or 49 feet—the effect upon the calculated velocity of the wave would have been only about a sixteenth, or 2.18 miles per hour.

The form and character of these deep-sea waves became at the same time interesting subjects of observation and consideration. In respect to form, we have perpetual modifications and varieties, from the circumstance of the inequality of operation of the power by which the waves are formed. Were the wind perfectly uniform in direction and force, and of sufficient continuance, we might have in wide and deep seas waves of perfectly regular formation. But no such equality in the wind ever exists. It is perpetually changing its direction within certain limits, and its force too, both in the same place and in proximate quarters. Innumerable disturbing influences are therefore in operation generating the varieties more or less observable in natural sea waves.

In regard to my own observations of the actual forms of waves, nothing particularly new could be expected from an inquiry of this kind in regard to phenomena falling within the perpetual observation of seagoing persons; yet, at the risk of stating what might be deemed common, I will venture to transcribe from my notes made with the phenomena before me, the leading characteristics which engaged my attention. During the height of the gale (March 6th) the form of the waves was less regular than after the wind had, for some time, begun to subside. Though in many cases when the sea was highest the succession of the primary waves was perfectly distinct, it was rather difficult to trace an identical ridge for more than a quarter to a third of a mile. The grand elevation in such case sometimes extended by a straight ridge, or was sometimes bent as of a crescent form, with the central mass of water higher than the rest, and, not unfrequently, with two or three semi-elliptical mounds in diminishing series, on either side of the highest peak. These principal waves, too, it should be noted, were not continuously regular, but had embodied in their general mass many minor, secondary, and inferior waves. Neither did the great waves go very prevalently in long parallel series like those retarded by shallow water on approaching the shore; but every now and then changed into a bent cuneiform crest with breaking acuminating peaks. On the following morning (March 7), after a second stormy night, wind S.S.W. (fine), we had a heavy and somewhat cross sea (from the change of wind from W.S.W. to S.S.W.). But the almost unabated magnitude of the more westerly waves indicated a continuance of the original wind

at some distance astern of us. The gale had moderated at daylight, and the weather became fine; but as the sea still kept high, its undulations became more obvious and easily analysed. At three in the afternoon, when about a third part of the greater undulations averaged about 24 feet from crest to hollow, in height, these higher waves could be traced right and left as they approached the ship to the extent of a quarter of a mile on an average, more or less. Traced through their extent the ridge was an irregular roundbacked hill, precipitous often on the leeward side of waters. The undulations, indeed, as to primary waves, consisted mainly of these roundbacked masses, broken into or modified by innumerable secondary and smaller waves within their general body. The time in which these waves passed the ship was now, on an average, about 15 seconds, the ship's speed being increased from 8 to 11 knots, and the obliquity of the ship's course to the direction pursued by the waves was 3 points. On the 8th, two days after the above condition of the waves—whilst the sea yet ran high—few waves could be traced continuously above 300 or 400 yards in extent along the same ridge. The crests often curled over, but none so as to reach the height of a 30-foot wave, and broke for a wide space, estimated at 50 to 100 yards in continuity.

Miscellaneous Notes and Suggestions.—The mode adopted in these researches of finding the height of wave is, I believe, quite satisfactory, and, observed with care and with relation to numbers or proportion of waves, as accurate as need be. The depression of the horizon in respect to the elevation of the observer is too small to form even a correction. As the horizon from the paddle-box $\psi = 15$ feet, had only a depression of $3' 40''$, the distance of the visible horizon, as seen from this elevation, would be 4.45 statute miles, and the actual depression in feet due to the distance of the summit of the wave when the ship was in the midst of the hollow, could only be 0.14 foot or 2.16 inches. Other modes of determining the width of a wave—or the extent betwixt summit and summit—much preferable to that described (the only available one I could devise) might easily be adopted where the management of the ship was in the hands of the observer. In steam ships the simplest mode for high seas, perhaps, would be, altering the speed of the ship when going in the direction of the wave or against the wave; the ratios of the times of transit of wave-crests, under different rates of sailing of the ship might yield results very close to the truth. In moderate-sized waves the plan adopted by Capt. Stanley—whose observations I met with before this meeting—seem satisfactory. But in calms, or moderate weather after a storm—that is, for the determination of the velocities of less elevated waves—a variety of processes might be available.

Mr. JOHN SCOTT RUSSELL observed that there were great doubts as to the actual heights of waves. It was now beyond a doubt that we had waves 24 feet, 30 feet, and 43 feet high, and with the swelling crest even exceeding 45 feet high. From the observations which he had conducted many years since, he had ventured to draw up a table predicting the velocities of sea waves up to even 1000 feet from trough to crest in length. Although the apparatus which he had used did not enable him to experiment on waves which exceeded 16 inches in length, yet from these pigmy waves it was most interesting to see how accurately the law was obtained; for in his table the velocity of a wave whose length was 559 feet was set down at 30 or 31 miles per hour. Dr. Scoresby's actually-observed velocity for a wave 559 feet in length was 32 miles and a fraction.

SHIP BUILDING ON THE WAVE PRINCIPLE.

The following communication from Mr. DODGSON, of the Ponta de Arés Iron Works and Dockyard, Rio de Janeiro, to Mr. John Scott Russell, was read:—

Sir—Having been called upon late in the year 1846 to undertake the management of the above establishment (then lately organised), my attention in the ship-building department was more particularly directed to the scientific and elegant system of construction advocated by you, of which I had some information from reports in the *Civil Engineer and Architect's Journal*. Not being fortunate enough, however, to obtain any information from England respecting the "wave principle," but convinced in my own mind of the correctness of the few leading features which I had thus been enabled to collect, I determined to attempt carrying them out in two small steamers, and two brig schooners (of 240 tons) then about to be laid down (October, 1847). This I was prevented doing to the full extent on that occasion, by the opposition of the parties for whom these vessels were building, supported by the very decided

opinions of all my colleagues, the resident engineer and shipwrights; the result, however, of the approximation which I was enabled to effect, was so far satisfactory that of the two steamers (propelled by sister engines), the larger of the two on these lines proved much superior, both in speed, stability, and in fact in every quality of a good passenger-boat, to the smaller lines of which, for the sake of a fair trial of system, I accepted from the Government Naval Architect, giving my vessel purposely larger dimensions, both as to length and breadth, the vessels being destined for the Bay, the direct resistance of the immersed mid-ship sections being, however, the same in each; the advantage gained in speed was as 7 to 8, and this superiority is since maintained: the sailing vessels also gave satisfaction, being reported, after trial at sea, as very "superior sea boats," "stiff," and remarkably easy under sail, neither pitching or "scending" in heavy seas, although not very remarkable for "speed," (this quality having been since obtained by alteration of masts and sails.)

Encouraged by these results and having in the interim obtained a copy of Mr. Fishbourne's very interesting Lectures upon the subject, I proceeded in May 1848, still in the face of great opposition, to lay down the keel of a small schooner of 123 tons, following in this design the proportions recommended by Fishbourne. The result was most satisfactory, being reported, after a four months' voyage to different ports, to possess all the properties of an excellent sea boat—speed, weatherly qualities, sufficient hydrostatic stability, and great hydrodynamic (both longitudinal and lateral) stability. The master expressing himself in the highest terms of her performance, after paying proper attention to ballasting and rigging, which was not done on leaving this port. The result has been an order, for the government, of a similar vessel, for a "guarda costa." About the same time I launched a steam tug of 230 tons, and 90-horse power, destined for the heavy rolling bar of Rio Grande; her lines were also assimilated as much as such service would justify to the proportions recommended. She has now been for some months on that dangerous station, giving great satisfaction, having also made the shortest passage on record to her place of destination, and having proved herself on her trials here equal in speed to the largest steamboats of our packet company.

I have lately launched the "guarda costa" (not yet tried), and a small armed steamer, also for government (for river service and drawing 42 inches of water), both built on wave principles, and of which I take the liberty of enclosing the lines, as also of the schooner, and a small steamboat for the use of the establishment. The government steamer has just been tried, and I flatter myself will settle the question here "as to lines," her performance being most satisfactory, overcoming the "resistances," imperceptibly dividing and leaving the water almost without a ripple (at 10 knots), with very little power (two engines of 20-horse power, of Miller's). My colleagues, however, are not yet convinced of the advantages of the "full water line, aft," insisting that the sharp line would have still improved her. I must confess, myself, however, of your opinion, and I consider this as one of the most scientific and valuable points of the theory.

I am now engaged with two large steamers for government, one of 430 tons well forward; the other of 360 tons, also laid down: but as I have not been able to overcome the mistaken desire to place very heavy artillery on the forecastles, I have been obliged to adopt a rather fuller entrance line than I should have wished, approaching more to the wedge shape. Time however is required, I find, even in England, to overcome prejudices, so that we cannot expect otherwise in these countries, where the sciences and arts are in the hands of empirics, with a very few honourable exceptions, and where we have not only prejudice but envious and interested motives to combat.

I should now crave your indulgence for occupying your attention with these particulars; but I am persuaded that as the advancement of science must be an object of interest to you, its progress in this remote quarter will not be a matter of indifference as respects the system of rather the relative proportions. I should wish to offer to your consideration a few remarks, but cannot allow myself this liberty until I have the pleasure of knowing that such observations may not be considered presuming from a person who has not the advantage of your acquaintance, but whose object is also the development and progress of the arts, and whose attention has been long directed, and is now chiefly devoted to the subject of naval architecture. This being also his only excuse for the liberty of addressing you.

That the advantages which must certainly attend the introduction of the system may be attributed in this country to their ori-

ginal proposer and distinguished advocate, I have further taken the liberty of directing your name to be given and carved upon the stern-sheets of a large passenger boat (latterly rigged) also built here on your principles, and now plying on our magnificent Bar, bearing away the palm from all competitors.

I am, &c.

THOMAS BUTLER DUDSON,
Naval Architect.

On the Dynamic Equivalent of Current Electricity, and on a fixed scale for Electromotive Force in Galvanometry. By Mr. W. PETER.

The dynamic value of a current of voltaic electricity is represented by the product of the rate at which electro-chemical action is taking place at any cross section of the current, (in other words, the quantity of the current,) and the electromotive force with which the current is sustained, which may be briefly termed its energy or intensity, (provided the idea of quantity be kept distinct from this.) The first object was to secure such units of comparison for both these elements as should be at all times recoverable. This is given in respect of quantity by the rate of chemical action, and the atomic weights. In respect of intensity of the current, we have no such fixed data, and the intensity of most voltaic arrangements cannot be relied on as constants for comparison. But the elements of Daniell's Battery, and those of nitric acid batteries with negative surface of platinum, carbon, or cast-iron, give an electromotive force or intensity that can be recovered with considerable exactitude, if uniformity of circumstances, materials, &c. be tolerably attended to: these, therefore, may be used to give a fixed and recoverable point in a galvanometric scale of intensity. Now it so happens, that if we assume the degrees of the scale to be of such a size that the intensity of Daniell's (standard) elements shall be 60 of the degrees, temperature being 70 Fahr.—that of nitric acid batteries will be from 100 to 112 of the same degrees; the author, therefore, has always used this scale, to which all other voltaic arrangements can be referred. Which scale, he would suggest, would be most conveniently used in assigning the electromotive power of electric currents from any source. The mean result of careful experiments, tried directly and conversely, is that a voltaic current of one unit in quantity, (or that from one grain of zinc electro-oxidized per minute,) and of 100 degrees intensity, represents a dynamic force of 302½ pounds raised one foot high per minute. This datum is of great interest as a scientific truth in connection with the other correlative agents of nature, (heat, electricity, light, and chemical affinities, neuralgic power, &c.) most of which we may hope soon to see reduced to a mutually comparable relation to each other, in terms of the great centre and medium of comparison, mechanical force.

On the Chemical Composition of the Rocks of the Coal Formation. By Mr. HENRY TAYLOR.

Mr. TAYLOR pointed out the analogies of constitution between certain rocks, and referred to experiments made by him on organic and inorganic constituents. The author had in view the solution of the difficult problems connected with geology, by facts deduced from chemistry; for instance, the deposition of the stratified rocks as to their order, &c., by a process of reasoning based on the composition of these rocks, and to this end he submitted several analyses as a small contribution to our knowledge of the rocks of the coal formation. Details of the analyses of fire-clay, specific gravity 2.519, good coal, specific gravity 1.259, coarse coal, specific gravity 1.266, bituminous shale, specific gravity 1.860, blue shale (slate-clay), specific gravity 2.533, micaceous sandstone, specific gravity 2.598, marble band, specific gravity 2.592, and of cannel coal, specific gravity 1.311, were given, and a comparative view of the analyses seemed to suggest a pretty close connection between various members of the group, taken principally from "Buddle's Hartley" colliery in the Newcastle coal field. The organic matter intermixed with the various strata enclosing the coal appeared to be of the same composition as the coal itself, except that its decomposition had been carried further. The inorganic matter of these strata likewise evidenced a close connection among them, though owing to the greater number of constituents, this could not be so readily shown. Formulae for the two classes of matter were given, and Mr. Taylor, in conclusion, hoped that the results of his analyses were sufficiently interesting to lead others into the same field of inquiry, and eventually to a right appreciation of the laws which regulate the deposition of the stratified rocks.

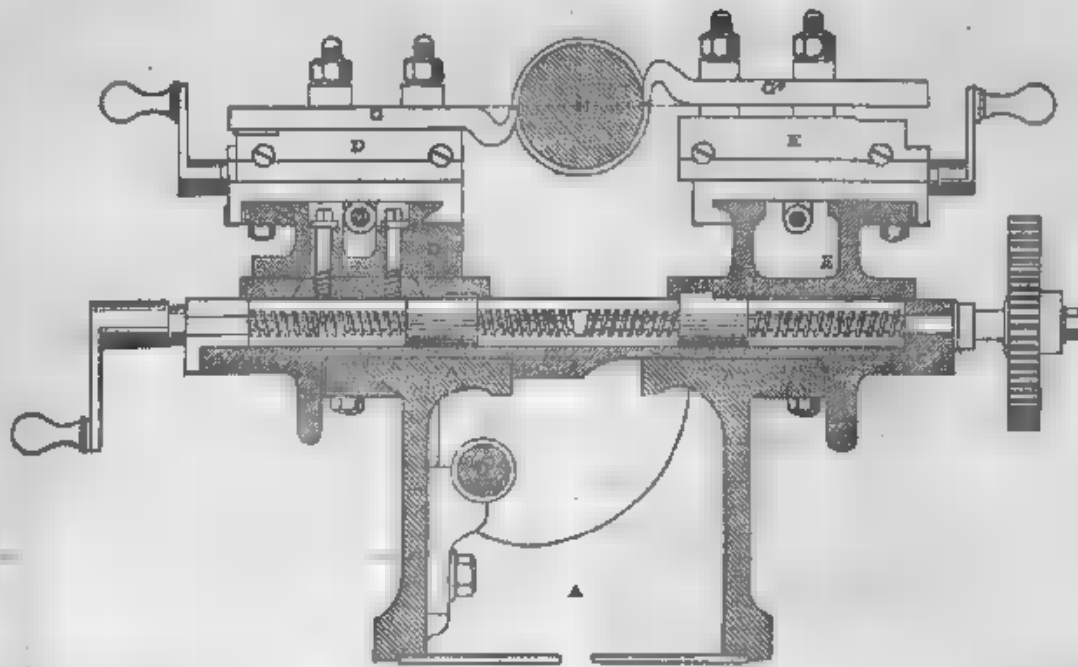
Notice of the Working of the New Integrating Anemometer during the past year. By Mr. FOLLAT ORLAA.

A sheet of plain paper placed in the instrument under a registering pencil is moved forward by rotating hemispherical fans, at the rate of one inch for every ten miles of air that passes; this same pencil, having a lateral motion given to it by a vane, records the point of the compass from which the wind blows, and a clock hammer descending every hour strikes its mark on the margin of the paper to express the time. Thus, in a single line are given, firstly, the length of the current; secondly, the direction of it; and thirdly, the time occupied in passing a given station marked hourly or at any shorter interval that may be desired.

WHITWORTH'S PATENT DUPLEX LATHE.

A paper was read from Mr. Whitworth, describing his new lathe. It is equally applicable for cylindrical or surface turning, or for cutting screws. The tools are shown as applied to cylindrical turning or screw cutting. For surface turning they would be placed at right angles to the position shown, and a self-acting motion given to the right and left hand screw. The top slide-rests are both provided with compound slides, whereby each tool may be adjusted to the work independently; and when once adjusted, the right and left hand screw only is used. Not only is

double the work performed in the same time, but in long objects with a less expenditure of power, owing to the saving by the lessened pressure against the stay. The work done is of a superior kind, there being a perfect balance of forces, and consequently less vibration; and from the increased duration of the tools, only one-half the amount of error takes place. Messrs. Whitworth have five of these lathes in use in their establishment, and the work produced by them is of better quality and at half the cost it was formerly from the single lathe.



The annexed engraving is a transverse section of the lathe. A, is the bed; B, the guide screw; C, the bottom slide-rest or carriage; D, a compound top slide-rest in front of the lathe; E, a second compound top slide-rest at the back of the lathe; F, a right

and left-hand screw for moving the two top slide-rests simultaneously to or from the centre of the lathe; G, G*, represent the two tools, namely, one in front and the other at the back of the lathe; H, represents a shaft under the operation of cutting.

(The remainder of the Papers read at the British Association will be given next month.)

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM JULY 25, TO AUGUST 22, 1850.

See Month allowed for Enrolment, unless otherwise expressed.

Rodolphe Helbrauer, of Regent-street, Middlesex, for improvements in preventing the external air, and dust, and noise, from entering apartments.—July 31.
 Thomas Dickson Koch, of Grosvenor House, Ayr, N. B., Esq., for an improved mode of manufacturing soap.—July 31.
 Matthew Trites, of Rochester, Kent, tool maker, for certain improvements in saws, millers, and other tools, and in apparatus and machinery for manufacturing the same.—July 31.
 John Shewell Gashin, jun., of Barbadoes, West Indies, gentleman, for improvements in the manufacture of rum. To extend to the colonies only. (A communication.)—July 31.
 Richard Archibald Broome, of the firm of J. C. Robertson and Co., of 185, Fleet-street, London, Patent agent, for an improvement or improvements in abdominal supports. (A communication.)—July 31.
 James White, of Highbury, Middlesex, mill maker, for improvements in machinery for bruising, crushing, and for expressing juice from certain vegetable substances.—July 31.
 Henry Bessemer, of Baxter House, St. Pancras-road, Middlesex, engineer, for certain improvements in apparatus acting by centrifugal force, in the manufacture of sugar, and other improvements in the treatment of saccharine matter by such apparatus.—July 31.
 Juan Napomuceno Adorno, of Golden-square, Middlesex, gentleman, for improvements in manufacturing chrys and other similar articles.—July 31.
 Henry Ashton, of Kenil, Westmoreland, plumber, for certain improvements in water-closets and urinals.—July 31.
 Joseph Poole Parnson, civil engineer, New York, America, for certain improvements in steam machinery and apparatus connected therewith.—July 31.
 John Hynam, of Prince's-square, Finsbury, Middlesex, chemical-light manufacturer, for improvements in machinery for placing splints of wood, and wax, and composition tapers, in frames for dipping.—July 31.
 John James Greenough, of George-street, Hanover-square, gentleman, for improvements in obtaining and applying motive power.—July 31.
 Peter Fairbairn, of Leeds, York, machinist, and John Hetherington, of Manchester, for certain improvements in machinery or apparatus for preparing, spinning, and weaving cotton, flax, and other fibrous substances; also in constructing and applying models or patterns for moulding, preparatory to casting parts of machinery employed in preparing, spinning, and manufacturing fibrous substances; and also in certain tools to be used in making such machinery.—July 31.
 Matthew Gray, of Morris-place, Glasgow, practical engineer, for an improved method of supplying steam-boilers with water.—July 31.
 Edouard Gabriel Leroy, of Paris, France, gentleman, for certain improvements in locomotive engines, and in the means and apparatus to be employed for generating and condensing the steam to be used therein.—July 31.

Joseph Shaw, of Paddock, Ruckersfield, York, clock balancer, for improvements in constructing and working certain parts of railways.—August 5.
 John Gwynne, of Lansdowne-lodge, Notting-hill, merchant, for improvements in obtaining motive power, and in applying the same to giving motion to machinery. (A communication.)—August 5.
 Francis Keane, of Berner's-mews, Middlesex, chair maker, for improvements in rolling chairs, in castors for chairs and other articles of furniture, and improvements in pieces.—August 5.
 William Crosskill, of Beverley, York, civil engineer, for improvements in mills for grinding, splitting, pulverizing, and crushing grain, bones, bark, ore, and other hard substances, and for grinding paint and other soft substances, and for shelling or removing the skin from rice and other grain, and in machinery for giving rotary motion to mills, thrashing machines, and any other machine requiring rotary motion to be communicated by any horse or other animal. (A communication.)—August 5.
 Joseph Steele, of Chancery-lane, for improvements in coating and impregnating metals and metallic articles. (A communication.)—August 5.
 Henry Meyer, of the Strand, Middlesex, gentleman, for certain improvements in power looms for weaving.—August 10.
 Solon Richard St. Clair Blaisdel, of Aldersgate-walk, New Broad-street, London, for improvements in the manufacture of artificial marble and stone, and in treating marble and stone.—August 10.
 Alfred Holt, of Greenwich, Kent, engineer, for improvements in steam-engines.—August 12.
 Armand Nicolas Fréche, merchant, residing in Paris, for improvements in obtaining power.—August 12.
 Charles Gidley, of Ligonier-street, Middlesex, pianoforte-maker, for improvements in stringed musical instruments.—August 12.
 George Thompson, of Park-road, Regent's-park, Middlesex, gentleman, for certain improvements in machinery and apparatus for cutting, digging, or turning up earth, applicable to agricultural purposes.—August 12.
 Samuel John Pittar, of Church-place, Clapham, Surrey, civil engineer, for certain improvements in umbrellas, and parasols.—August 12.
 Peter Clausen, of Great Charlotte-street, Blackfriars, Surrey, manufacturer, for certain improvements in bleaching, and in the preparation of materials for spinning and felting, and in yarns and felts. (A communication.)—August 13.
 William Kemler, of Liverpool, merchant, for improvements in machinery for manufacturing rollers and cylinders used for calico printing, and other purposes.—August 16.
 Charles Heald Wild, of St. Martin's-lane, Middlesex, civil engineer, for improvements in certain structures for retaining water.—August 17.
 Henry Belland, of Birmingham, umbrella furniture manufacturer, for improvements in the manufacture of umbrellas and parasols.—August 22.
 Edouard Anatole Chomeroz, of Paris, for improvements in paving streets and other surfaces.—August 22.
 Frederick Hale Thomson, of Berner's-street, Middlesex, gentleman, and Thomas Robert Mettish, of Portland-street, Middlesex, glass-cutter, for improvements in cutting, staining, silvering, and flaring articles of glass.—August 22.

LECTURES ON THE HISTORY OF ARCHITECTURE.

By SAMUEL CLEGG, JUN., M.I.C.E., &c.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, MR. GEORGE THE DUKE OF SUCCESSION, &c.)

Lecture IX.—ROME.

The Five Orders—Masonry—Temples—Sepulchres.

HAVING already described Rome as it existed under Etruscan domination or influence, it is needless to revert to its early history. After the expulsion of the Kings, the stern republican spirit that prevailed caused the Romans to neglect the fine arts as tending to enervation and a love of luxury; a nation of warriors, their sole aim was to increase the territory and power of Rome. That the buildings of republican Rome, however, were thought worthy of attention, is proved by the appointment of *adiles* or magistrates, who had the care of their preservation, an office first created in the 206th year of Rome: but they were for the most part simple and unadorned. The solid and plain Tuscan order satisfied the taste of the people; nor did they seek for farther embellishment.

The materials within the power of the Romans in the time of the commonwealth were by no means favourable to decorative architecture; the dark peperino, the tufa of the Campagna, and the porous travertine, could not vie with the marbles of Greece and Asia; and Rome was not yet enriched with foreign spoils.

In the time of Camillus, who died 365 B.C., Rome was reduced to ashes; and the rude cottages of the city of Romulus were afterwards replaced by buildings of a more solid and convenient description. But a still greater change took place on the conquest of Greece and Sicily. Horace says, "Greece, when subdued, captivated the fierce conqueror, and brought the arts into rustic Latium."

Notwithstanding the persuasive influence of beauty, the old simple habits did not at once give way, and Cato still railed against the importation of statues and paintings as the introduction of so many enemies to Rome. But when a more refined and cultivated taste once made good its entrance, no censor could long stay its progress, and soon the victorious generals emulated each other in despoiling the conquered provinces for the adornment of their native cities. Metellus Macedonicus is said to have been the first to build a marble temple in Rome: he also erected a portico, in which he placed twenty-five equestrian statues, brought from Macedonia. His contemporary, Lucius Mummius, also brought rich spoils from Corinth; but betrayed his ignorance of what he had acquired, by threatening that those who had charge of the transport of the splendid statues and paintings, should be made to replace any that were lost or injured. At the triumph of Paulus Æmilius, on his return from Greece and Macedonia, 330 chariots were barely sufficient to carry the works of art brought in his train. When we consider that these continued to be accumulated year after year, we read without surprise that the number of statues in Rome formed another population.

The first mention we find of the quarries of Luna or Carrara, is in the time of Julius Cæsar. The prefect of Cæsar's army in Gaul caused his house to be lined with this beautiful material, and every column to be sculptured in solid Carrara or Corymbian marble. In a few years the residences of the Roman patricians vied with those of the eastern potentates in magnificence. Rich marbles were brought at an enormous expense from Greece, Asia, and Egypt. Where these could not be afforded, painted imitations were substituted, or inferior marbles were stained to represent those of a more costly description.

In the time of Augustus Cæsar, a second conflagration devastated the city; after which it was restored with increased splendour, giving rise to the saying of Augustus, that he had found Rome of brick, and left it of marble. The architects and artists of Greece flocked to imperial Rome, where they were sure of finding patronage and employment, and principally under their superintendence were erected the temples of Mars Ultor, Jupiter Tonans, Apollo Palatine, and others, besides the theatre of Marcellus, and several porticoes, public libraries and other buildings. The celebrated Vitruvius (better known by his writings than by his architectural works) belongs to this period. His treatise on architecture is the only book on the subject remaining to us from the classical age. The example of Augustus was followed by his successors, who emulated each other in the embellishment, not only of Rome, but also of the provincial cities. Another and most disastrous conflagration occurred in the reign of Nero, when fourteen quarters

or districts of the city were utterly destroyed. Rumour pointed to the emperor himself, as the wilful author of this calamity. Ruffians were seen while the fire was raging rushing about with lighted torches, throwing them where most like to ignite the surrounding materials, and preventing the wretched populace from attempting to extinguish the flames. Nero, to remove the odium of the deed from himself, accused the Christians, who were consequently made to suffer unheard-of tortures. Many valuable specimens of Greek art were lost in this fire, but a great improvement was apparent when the city was rebuilt, in the increased regularity and width of the streets, and greater commodiousness of the houses. Magnificent, however, as were the restorations of Nero, art could not be expected to flourish in its pristine purity under a patron who gilded some of the statues and cut off the heads of others, in order to substitute his own.

During the reigns of Trajan, Hadrian, and the Antonines, Rome still continued to increase in opulence and splendour; it was indebted to Trajan for some of its noblest monuments, erected by the architect Apollodorus. The Emperor Hadrian was an architect himself, and a great builder. Many structures were erected by him in Italy and the provinces of the empire; and in several places whole cities arose at his command, as at Athens and Jerusalem. Unfortunately, vanity and cruelty were united with taste and magnificence in the mind of this emperor. He was accustomed to employ an architect of the name of Detrianus to execute his designs, who was too good a courtier to criticise; but wishing for the approval of the more celebrated Apollodorus, Hadrian submitted to this great artist a plan for a Temple of Venus: the too candid Apollodorus dared to laugh at the design, saying that if the statues seated there were inclined to get up, they would knock their heads against the disproportionately low ceiling. This censure cost the unfortunate architect his life. He was put to death by order of his offended master.

From the time of the Emperor Decius (230 A.D.) Rome rapidly declined. Incessant wars drained the revenue, and required the presence of the emperor abroad. Under Dioclesian, the seat of government was removed to Nicomedia, on the sea of Marmora; and to Milan, where Maximian held his court; and in 330 A.D., the final blow was given to ancient Rome by the foundation of the new capital of Constantine the Great.

Gibbon quotes the following passage from the writings of Poggius, who described Rome in 1430, A.D.:—"Her primeval state, such as she might appear in a remote age, when Evander entertained the stranger of Troy, has been delineated by the fancy of Virgil. This Tarpeian rock was then a savage and solitary thicket. In the time of the poet, it was crowned with the golden roofs of a temple: the temple is overthrown, the gold has been pillaged, the wheel of fortune has accomplished her revolution, and the sacred ground is again disfigured with thorns and brambles. The hill of the Capitol on which we sit was formerly the head of the Roman empire; the citadel of the earth; the terror of kings; illustrated by the footsteps of so many triumphs, enriched with the spoils and tributes of so many nations. This spectacle of the world, how is it fallen?—how changed?—how defaced?—the path of victory is obliterated by vines, and the benches of the senators are concealed by a dunghill. Cast your eyes on the Palatine hill, and seek among the shapeless and enormous fragments, the marble theatre, the obelisks, the colossal statues, the porticoes of Nero's palace. Survey the other hills of the city: the vacant space is interrupted only by ruins and gardens. The forum of the Roman people, where they assembled to enact their laws and elect their magistrates, is now enclosed for the cultivation of pot-herbs, or thrown open for the reception of swine and buffaloes. The public and private edifices that were founded for eternity lie prostrate, naked, and broken, like the limbs of a mighty giant; and the ruin is the more visible, from the stupendous relics that have survived the injuries of time and fortune."

Notwithstanding many new architectural features, the offspring of new wants, the Romans were far from being an inventive people; they were indebted for their peculiar style to the united influence of Greece and Etruria: from the former they received the Orders, from the latter the arch and the knowledge of vaulting. In Roman architecture we find five orders; the Tuscan, Doric, Ionic, Corinthian, and Composite. The Tuscan order appears to have fallen into disuse after the time of the Commonwealth, for though described at length by Vitruvius, scarcely an ancient example remains. The Greek-Doric was superseded by the Roman, of a more light and ornamental character; the height of the column was increased from four or five to eight, or eight and a half diameters; the shaft was finished by an astragal and fillet; the

hypotrachelium or necking between this and the ovolo was frequently ornamented with roses or other devices; to the abacus is added an ogee and fillet round the upper edge, and the shaft is generally plain. Fine specimens of the Roman Doric are to be seen in the theatre of Marcellus and the amphitheatre at Nîmes; most of the examples of this order have the attic base. The frieze, instead of being finished by triglyphs at the angles, according to the Greek method, was generally terminated by a half metope; the metopes were seldom so richly sculptured as in the Greek order, a simple patera or wreath, or ox-skull adorned with festoons, was repeated in each, or alternated. The dentil was sometimes introduced in the cornice instead of the mutula, and the face of the entablature was perpendicular with the upper diameter of the column. The Doric order was seldom used, except where the building was to rise to the height of two or more stories, when the Doric was placed as the lowest order; in the amphitheatre at Nîmes, both stories are Doric. The Ionic order is comparatively with the Corinthian and Composite, rarely met with, and is in most instances a mere copy from the Greek; the Temple of Concord, however, is a singular exception, in this the capitals have the form of the upper part of the Composite, with small angular volutes, a cable ornament, and enriched cyma, torus, and fillet below. Amongst the numerous fragments discovered in Italy in an Ionic capital, the volutes of which are an exact representation of the horns of a ram, greatly strengthening the supposition of such having been their origin. The most beautiful example of the Ionic order in Rome is the Temple of Fortuna Virilis,* supposed to have been erected by a Greek architect. There is a difference of opinion as to whether the Corinthian or Composite should be placed first; but as both Palladio and Vignola give precedence to the Corinthian, I cannot greatly err in following their example. The Corinthian became the favourite order in Imperial Rome, and was repeated (though with great variety of detail) so endlessly that the eye becomes wearied with excess of magnificence. We undoubtedly owe our most finished examples of this order to the Romans; amongst which, for beauty and elegance of design, the exquisite columns of Jupiter Stator* stand unrivalled. Only three columns with their entablature remain standing, the whole composed of the finest white marble. The columns are ten diameters in height, the shafts diminish nearly $\frac{1}{4}$ th, and have twenty-four flutings; in the capital, the second row of leaves are lower than in the rule given by Vitruvius, leaving more room for the sweep of the cauliculi and scrolls; the intertwining tendrils in the centre have a particularly light and graceful effect; the cornice is high; one modillion is placed over each column and three in the interval; the modillions are peculiar in having the volutes of equal size. In the Temple of Vesta at Tivoli, the second row of leaves are still lower than in the former example; the scrolls rise without cauliculi, and are so large as almost to approach those of the Composite order; behind the second row of acanthus is a small row of water leaves, the tops of which touch the bottom of the scrolls.

It is worthy of observation, that while in the pure Greek-Corinthian, either the wild or cultivated acanthus was always closely imitated, in the Roman the foliage generally took the form of the olive leaf, though with the growth of the acanthus; this may be seen in the capitals of Jupiter Stator, Mars Ultor, and many others. The following examples will show the varied proportions of columns of the Corinthian order:

	Lower Diameter.		Height.	
	ft.	in.	ft.	in.
Temple of Antoninus and Faustina	4	6 $\frac{1}{2}$	43	3
Temple of Jupiter Stator	4	5 $\frac{1}{2}$	45	2 $\frac{1}{2}$
Basilica of Antoninus or Temple of Mars 4	6 $\frac{1}{2}$		46	5 $\frac{1}{2}$
Temple of Mars Ultor	6	0	58	0

The proportions of the entablature vary in different examples from one-fifth of the height of the column to one-fourth or more. In the Temple of Antoninus and Faustina, the cornice has neither dentils nor modillions, but the frieze is enriched with figures of griffins, candelabra, and scrolls. The Arch of Titus has been said to be the earliest example of the Composite order, but this appears to be a mistake, as this order is seen in the atrium of the house of Pansa in Pompeii, which was destroyed several years before the Arch of Titus was erected. Some authors deny the claim of the Composite to be described as a separate order, and consider it merely as a variation of the Corinthian, but as it has several distinctive features, it saves confusion to allow it to retain its place as a fifth order. The capital is formed by a union of the Ionic and Corinthian; it is somewhat deeper in proportion than

the latter, and like it is divided into three parts; the first occupied by the angular volutes, with the intervening torus and astragal; the second by the upper, and the third by the lower range of acanthus leaves; the fillet below the astragal forms the lip of the vase. This is the usual form, but the Romans frequently varied it, and sometimes with great elegance and propriety. In some instances, the centre flower of the abacus is replaced by the figure of an eagle, as in the Portico of Septimius; in others, the eagles occupy the place of the volutes at the angles, with Jupiter's thunderbolts in the centre; in other examples, ox-skulls are placed at the angles, with a festoon between, the lower part of the capital being finished with a row of water leaves, and so on in infinite variety. The shafts too were either plain or capriciously ornamented, some with spiral flutings, as in the Baths of Dioclesian, and others with wreaths of leaves, as in the Temple at Spoleto in Umbria; the flutings were frequently filled in with cablings part of their height, as in the Baths of Nîmes, where the shaft springs from a row of acanthus leaves above the base. These fancies were not confined to the Composite, but sometimes extended to the Corinthian; the attic base was applied to both orders. The entablature of the Composite resembled that of either the Ionic or Corinthian, but did not follow any positive rule. The mouldings in Roman architecture differ considerably from the Greek, and seldom present so graceful a profile; they are rounder and more prominent, and the enrichments are bolder and more profuse. The frieze in both the Corinthian and Composite orders is frequently swelled or rounded. The usual intercolumniation of the temples and porticoes was pycnostyle or $1\frac{1}{2}$ diameters, contrary to the recommendation of Vitruvius, who condemned both the pycnostyle and systyle as too narrow. "Neither of these species," he says, "ought to be generally adopted, for the matrons who go to their supplications mutually supporting each other, cannot pass through the intercolumniations unless they separate and walk in files." He alludes also to the obstruction caused to the view of the entrance; but this was obviated by making the centre intercolumniation of greater width than the others.

Contrary to the usual practice of the Greeks, the Roman pilaster capitals repeated those of the orders; in some instances the pilaster tapered upwards in the same degree as the column. The greatest distinctive feature in Roman architecture, however, was the introduction of the arch. It is almost impossible to imagine that the Greeks, having constant intercourse with both Egypt and Assyria, should have been ignorant of its mode of construction; it is a more probable conclusion, that they felt the want of harmony between the horizontal lines of the stylobate and entablature and the semicircular form; and having no occasion to roof in any large area (their great temples being hypæthral) they rejected the arch from choice rather than from want of knowledge. The vast multitudes that flocked to Rome rendered it necessary to erect public buildings of much greater magnitude than had been required in any of the cities of Greece; besides which, the humidity of the climate rendered a covering more desirable: thus the principle of vaulting was brought into use, as any space that could be spanned by a beam of wood or block of stone would have been inadequate to the wants of the population. The use of the arch naturally produced great changes; where introduced, the walls became the principal support of the roof, and the columns being merely ornamental accessories, were lighter, and further apart. At first the arch was entirely independent of the order, springing from imposts behind the column, and not reaching so high as the entablature. The imposts and archivolts had only a few simple mouldings, but the key-stone was frequently sculptured with a head or mask, or ornamental console. In the time of Hadrian the imposts were made in the form of pilasters, or the arch sprung from the architrave above the columns; thus breaking the frieze and cornice, and destroying the horizontal line hitherto so strictly preserved. To this succeeded arches rising immediately from the capital of the column, the entablature being altogether omitted, as in the Emperor Dioclesian's palace at Spalatro, thus gradually leading to the Romanesque or early Christian style. The Roman arch was always semicircular, with plain wedge-shaped voussoirs of stone or brick, sometimes of stone and brick alternately. Vaulting came into use in Rome at the same time as the arch; the earliest kind was that called the Barrel or Wagon Vault, presenting a uniform concave surface throughout its length. Groining was also practised by the Romans, and formed by the intersection of vaults crossing at right angles. That domical vaulting was thoroughly understood we have a proof in the Pantheon. Another new feature was the pedestal as applied to architecture; this may be ascribed to two causes—the numerous wrought-marble columns brought from

* See Taylor and Ormy's Rome.

Greece and Asia Minor were too short for the places they were to occupy in the buildings of Rome; it was necessary, therefore, to give them additional height; this was sometimes done by adding a moulding between the base and the shaft, but generally by raising them on a pedestal. Secondly, the width given to the arcade required the order to be of a proportionate height, so that it must have been so massive as to have been out of character with the rest of the building, or the column must have been so slender in proportion to its height as to destroy its beauty. To avoid either of these defects the pedestal was employed, by which means the proper proportion of the order was retained. The height of the pedestal was regulated either by that of the column, or by the width of the arch. The roofs of the Romans were somewhat higher in pitch than those of the Greeks, the pediments were consequently slightly more elevated. Towards the decline of the empire, semicircular pediments were introduced, though they were mostly confined to niches, or interior decoration. At Nîmes, and at Bualbec and Palmyra, there are rows of niches in which semicircular and angular pediments alternate; here also are seen broken pediments, coupled columns, and other features unknown in the early times of classical architecture.

The Romans were never surpassed in any age, or by any people, in constructive skill. Brick-making was carried by them to great perfection; bricks were made of various forms, and of various sizes, from 8 inches square to 1 ft. 5 in. by 1 foot. A light kind was manufactured for vaulting, so light (according to some accounts), that they would float on water; these were much prized. The Romans employed several kinds of masonry, as the *opus incertum*, composed of stones of irregular shape and size; the *opus reticulatum*, formed with square stones laid diagonally; and the *emplectum*, the same with the *emplectum* of the Greeks. In these the stones were small, and laid with mortar; but when larger stones were employed no mortar was used. In great works the stones used by the Romans were sometimes of enormous size; the blocks of the architrave and frieze of the Portico of the Pantheon, extending from column to column, are each 15 feet in length, 6 ft. 8 in. in height, and nearly 6 feet in thickness; the angular blocks are above 17 feet in length; some of these stones weigh as much as 36 tons. At Bualbec, many of the stones are from 29 to 37 feet in length, and 9 feet in thickness, and one measures 62 ft. 9 in. in length, in one single block. Towards the decline of the empire, the *emplectum* was much used, either with or without courses of tiles; this is the kind of masonry usually met with in the Roman works in England and France. Mortar was frequently made with pounded brick, which gave it a reddish tinge; but where procurable, the Romans used puzzolane. The puzzolane cement was of two kinds; one, blacker and more ferruginous than the other, was employed in buildings exposed to the action of water. The channels of the water-courses were laid with cement, two or three inches thick, and are still as smooth and compact as if chiselled out of solid stone. When any structure was to be preserved from damp a double wall was built, with about a palm interval between. The method of marking out foliage in decoration may here be mentioned: a deep circular hole was drilled at each division of the leaf, thus assisting the effect of light and shade, and giving great boldness and decision of character. The Romans were no less skilful as workers in metal; four bronze columns, of exquisite workmanship, are still preserved in St. John Lateran, supposed to have belonged to the Temple of Jupiter Capitolinus; and the bronze gates of the Pantheon, and several others, are still considered pre-eminent in beauty.

With the exception of the Pantheon, the Flavian Amphitheatre, and a few others, all the magnificent buildings with which the Imperial City was once adorned, are so completely in ruins, that Rome has not inaptly been termed "a marble wilderness." Of many of these ruins it is difficult—of some impossible—to trace the plan, or to decide upon their proper designation. Gibbon ascribes this devastation to four principal causes: injuries of time and nature, hostile attacks, use of materials, and domestic quarrels. Owing to their solidity of construction, time, unaided by other causes, might have spared us most of the great structures of classical times; but besides frequent conflagrations, Rome was formerly exposed to the floods of the Tiber, which often caused great destruction. This danger is now removed, as the city is raised fourteen or fifteen feet above its original level. Besides these causes of decay, Rome (in 410 A.D.), was plundered by the barbarians under Alaric; and afterwards another horde, under Genseric, pillaged the doomed city for fourteen days. Much of what the Goths and Vandals had spared fell a prey to domestic rapine. In the middle ages the remains of ancient Rome formed a vast

quarry, from which materials were unscrupulously taken for the construction of new edifices. The Coliseum owes much of its ruin to this cause; it is said, that as many stones were carried away from it in a single night as built the Farnese Palace. The Theatre of Marcellus became the Palazzo Orsini, and the Arch of Titus a fortress in the hands of the Frangipani family. Other buildings have been appropriated to different purposes, and extensive repairs and alterations been made, so that it is sometimes difficult to distinguish the new from the old: thus temples and basilicas have been converted into Christian churches, and statues of heathen gods made to do duty as Catholic saints. The same causes of decay prevailed in most of the provincial cities. The generality of Roman temples were similar in plan to the Greek, and were, like them, divided into the seven classes described in a former lecture; they were also frequently surrounded by an extensive peribolus, the wall of which was sometimes as high as the pediment of the temple. The peribolus wall was adorned within by a peristyle, or with niches and statues, and often contained apartments for the officiating priests. The principal difference between the Greek and Roman temples arose from the greater population of Rome, and the consequent greater space required. Thus in the prostyle temples, the porticoes were generally of the pseudo-dipteral form; and as they were mostly built on level ground, a greater elevation was given to the stylobate, in order to raise them above the surrounding buildings. A flight of steps, sometimes as many as twenty-one, led up to the portico in front; the acroteria on each side terminating the podium, were decorated with statues; and in the larger temples statues occupied the place of antefixes on the roof. The Romans adorned their temples with lavish profusion; when Domitian restored the Temple of Jupiter Capitolinus, the gilding alone is said to have cost 12,000 talents, a sum nearly equal to two millions sterling.

The Temple of Peace was one of the largest and most magnificent in Rome; the central aisle was 83 ft. in breadth, surmounted by a vault 150 ft. in height; three lofty arches, each 80 ft. span, yet remain; here were deposited the sacred vessels brought by Titus from the temple at Jerusalem.

One of the most perfect Roman temples now remaining is that of Calus and Lucius Caesar, generally known as the *Maison Carrée* at Nîmes. It is of the Corinthian order, 74 ft. in length, by 41 ft. in breadth; prostyle and hexastyle, with a pseudo-dipteral portico; engaged columns are placed round the exterior walls of the cella; the columns are rather more than ten diameters in height, and the capital, which is of elegant design, is somewhat more than one diameter high. The frieze in front is occupied by an inscription, but on the flanks is sculptured with foliage. The entablature rather exceeds $2\frac{1}{2}$ diameters in height; the doorway is elaborately ornamented, and surmounted by a lofty cornice. This temple is ascribed to the time of the Emperor Hadrian. Besides the seven classes, the Romans had another form of temple, derived from the Etruscans, and by them probably from the east; this was the circular, symbolical of the earth and the heavenly bodies, and dedicated to Vesta or Cybele. The Pythagoreans believed fire, which they called Vesta, to be the centre of the universe; and Plutarch mentions a circular temple, which the Etruscan King Numa Pompilius erected to contain the sacred fire. Several circular temples are still in existence, as the Temples of Vesta at Rome and Tivoli; but the greatest ever built, and also the one in best preservation, is that dedicated to Jupiter, Cybele, and all the gods, by Agrippa, son-in-law to Augustus, and called the Pantheon or Rotunda. It is uncertain whether the body of the edifice existed previously, Agrippa only adding the portico, or whether the whole may be ascribed to him; the former is probably the case. It was injured by fire some time after its erection, and was repaired by Septimius Severus and Marcus Antoninus. After suffering from neglect for many years, it was granted by the Emperor Phocas to Pope Boniface, who dedicated it to the Virgin Mary and the holy martyrs (610, A.D.). The Pantheon originally stood seven steps above the ground, but the earth has accumulated so much round it, that it is now below the level. The body of the temple is 143 ft. diameter, and 143 ft. in height to the top of the dome; it is constructed of brick; the exterior was formerly coated with stucco or cement, and the dome covered with plates of bronze, but these were removed by the rapacious Emperor Constantine, during his visit to Rome. The walls are 20 ft. in thickness, and gradually diminish to 5 ft. as they approach the summit of the dome. The exterior height is divided into three parts by cornices of brick; the two upper cornices have stone modillions; the second rises in front, so as to repeat the form of the pediment. From the third cornice, the wall recedes about 8 ft., then follows a podium

or subbase, and six steps, from which the dome rises. The two towers are modern, and were erected by Pope Urban VIII., part of the second cornice being cut away to receive them. The portico of the Pantheon is justly considered one of the most beautiful remains of antiquity. It is of the Corinthian order, octostyle, systyle, and dipteral. The sixteen columns supporting the pediment are 46 ft. 5 in. in height, and 5 ft. lower diameter; the shafts are plain, the exterior range of gray granite, the interior of red Egyptian granite in one block; the bases and capitals are of white marble; the entablature (also of white marble) is nearly one-fourth the height of the column. Opposite the interior range of columns are fluted pilasters of white marble, between which are bas-reliefs; the spaces between the pilasters on the flanks are also decorated with bas-reliefs. On each side of the doorway are niches, the one formerly occupied by the statue of Augustus, the other by that of Agrippa. Critics have objected to the depth of the tympanum, but it must be remembered that the Roman roofs were more elevated than those of the Greeks, on account of the difference of climate; and the effect of the high pediment would be much relieved by the sculpture with which it was formerly ornamented. The doorway is 39 ft. in height, and 19 ft. in width, with impostas and cornice of white marble; the doors are perforated at the top to admit of light and air.* The mass of brickwork of which the wall is composed, is lightened by seven exedrae or chapels, which surround the interior, and also by small vaulted chambers above; the weight over each opening is discharged by arches seen on the exterior. The chapels have each two Corinthian columns in *antia*, of giallo antico, or pavonazzetto marble; the architrave and cornice are of white marble, the frieze of porphyry; it is said, that before the restorations of Septimius Severus, the interior columns had capitals of Byzacusan bronze; the interior order is lighter in character than the exterior, and the shafts of the columns are fluted. Between the chapels are tabernacles, each with two isolated columns backed by pilasters. The large recess opposite the entrance was formerly occupied by a statue of Jupiter, but is supposed to have been altered from its original form for the reception of the high altar. Above the lower order is an attic with a continuous pedestal or subbase; it is now decorated with small pilasters and panels of different coloured marbles set into the wall, the pilasters having capitals of white marble in low relief; these are, however, comparatively modern, as anciently the entablature was supported by thirty-four caryatides or telamones. In the dome are deep caissons, twenty-eight in the circumference and five ranges in height; in the centre of each was a rose of gilt bronze; the plain part of the dome was silvered. The whole of this splendid edifice receives light from a circular aperture, 28 ft. diameter, called the eye of the vault; in the attic are fourteen windows, but these do not communicate with the exterior, but are intended to give additional light to the chapels from the centre opening. The pavement is tessellated with granite, porphyry, jasper, and marble; it inclines towards the centre to prevent the rain falling through the roof from deluging the floor. The aperture was occasionally covered by a velarium. Such is the Pantheon. "Spared and blest by time, simple, erect, severe, austere, sublime," as Byron describes it, we may imagine its imposing effect in its days of pristine splendour.

The circular temple of Vesta at Tivoli and Rome, are peripteral, the former surrounded by a peristyle of eighteen fluted Corinthian columns, 24 diameters in height; the latter, by twenty columns, nearly 11 diameters in height. In these small circular peripteral temples the interior diameter of the cella was the same with the height of the column; they were lighted by windows, and were supposed to have had vaulted roofs terminating in flowers or antefixes. From its picturesque situation on the edge of the cliff, the Temple of Vesta at Tivoli has been an unfailing subject for the landscape painter, from the time of Claude to the present day. Vitruvius mentions another kind of round temple, with a domical roof supported by columns without a cella, called *monopteral*: of these we have no examples.

Before leaving the subject of the sacred buildings of the Romans, the ruins of Baalbec and Palmyra claim our attention, both belonging to the latter ages of the empire. Baalbec, or Heliopolis, so called from the worship of Baal or the Sun, was one of the chief cities of Coele Syria, whose inhabitants were renowned in early times for their magnificence and luxury.

It is uncertain to which reign the great temple is to be ascribed; some authors attribute it to Antoninus Pius—others to Septimius Severus. John of Antioch says, "Elus Antoninus Pius built a great temple to Jupiter at Heliopolis, near Libanus, in Phenicia,

which was one of the wonders of the world. The ruins are so vast, that the Arabs believe the buildings to have been the work of fairies or genii. A grand portico leads into a hexagonal court, and this into a quadrangular peribolus, at the end of which is the great temple; in the first court are chambers, which are supposed to have been schools, and apartments for the priests. The portico, or propyleum, is flanked by projections or towers, on which modern fortifications have been raised. The great temple is of the Corinthian order, decastyle, with nineteen columns on the flank. It is 200 feet in length, and 450 feet in breadth; the columns are 7 feet lower diameter, 6 ft. 5½ in. upper diameter, and 58 feet in height. The whole height of the order is 87 feet. A smaller temple stands near, octostyle and pseudo-dipteral, also of the Corinthian order. The whole of the buildings are of white marble, and as sumptuously enriched as the luxury of art could devise. The ornament on the frieze is the same in both temples, and is most singular; it consists of a row of modillions set on end, connected by ribbons and garlands, with a grotesque head carved under the upper scroll of each modillion. A small temple still exists at Baalbec, in good preservation, which is unique in form. The cella is circular, 33 feet diameter, with a peristyle of eight columns, six of which are about 10 feet distant from the cella; the entablature curves so as to touch the wall, the columns only supporting the projecting angle formed by the meeting of two curves. The same elliptical curve is repeated in the stylobate; the frieze is rounded, and the wall of the cella ornamented on the exterior with niches.

Palmyra, rising like an island from the sandy desert, received its name from its multitude of palm trees. It is supposed to be the same as the Tadmor of King Solomon. This city long preserved its independence, on account of its situation in the desert, and as a frontier town between Parthia and the Roman empire, and carried on the principal trade between Rome, India, and Arabia. Palmyra is best known to us as associated with the names of Zenobia and Longinus. This once wealthy and important city, the abode of princely merchants, has now dwindled to a few miserable mud cottages, erected within the court of its once magnificent temple. The date of the foundation of the great temple is unknown; but from inscriptions it appears to have been repaired by the Emperors Hadrian, Aurelian, and Justinian. It is octostyle and pseudo-dipteral, and stands in the midst of a spacious peribolus, 740 feet long by 720 feet broad. The peribolus is surrounded on three sides by a double peristyle; on the west is the noble propyleum and the priests' apartments: the exterior wall is decorated with Corinthian pilasters. In the great portico or propyleum are the niches, with coupled columns and semicircular pediments before mentioned. The ornaments, particularly of the doorways and soffits, are elaborately beautiful. The whole of the ruins of Palmyra are of the Corinthian order, with the exception of four engaged Ionic columns in the great temple, and two in one of the tombs.

The architecture of Palmyra is precisely similar in style to that of Baalbec; both exhibit the florid taste of the east rather than the simplicity of classical art; but whatever defects may be perceptible, it is impossible not to admire the grandeur of the conception, the boldness of the execution, and the great skill displayed in construction. Before entering upon the civil architecture of the Romans, I shall briefly notice their tombs and mode of sepulture. It was the universal custom (with the exception of a few of their greatest men) to bury without the walls: monuments are therefore found extending on both sides of the roads, beyond the gates of the cities; they are of various forms, generally richly ornamented, frequently with bas-reliefs, painted in colours. The tomb of Cecilia Metella at Rome is a circular building, so massive that it at one time served as a fortification. The Castle of St Angelo was formerly the Mausoleum of Hadrian, built by that emperor as a depository for his own remains and those of his successors, several of whom repose there. It is a circular structure raised upon a square basement. It was originally cased with marble, and surrounded by a peristyle; but the columns, as well as the statues with which its summit was adorned, have long since disappeared.

The kind of sepulchre peculiar to the Romans, from their custom of burning their patrician dead, was the Columbarium, so called from its resemblance to a dove-cote. This was a square chamber with rows of arched recesses for the reception of cinerary urns or chests. In a niche opposite the entrance, a statue or bust of the founder of the family was frequently placed. The columbaria only received light from the funeral lamps or torches, borne by the mourners. Slaves, and those of the lowest rank, were buried in cemeteries at the public expense.

* See Professor Donaldson's *Examples of Ancient Doorways*.

The civil and domestic architecture of the Romans will be described in the next Lecture, beginning with the roads and aqueducts, and proceeding with the Fora, Basilica, Amphitheatres, Thermae, and other characteristic buildings.

LIST OF AUTHORITIES.

Vitruvius—Decline and Fall of the Roman Empire, Gibbon.—Archæological Antiquities of Rome, Taylor and Cory.—Les Edifices Antiques de Rome, Desgodets.—De Romanorum Magnificentiâ, Piranesi.—Le Cinque Ordini, Vignola.—Monumenti e Fabbriche Antiche, Cipriani.—Antiquités de la France, Clarissart.—Ruins of Babylon and Palmyra, Wood.—Pamphlet, Sir William Gell.—Encyclopædia Methodique—Architecture, Serlio.—Architettura, Palladio.

LIGHTHOUSE.

A LIGHTHOUSE of a somewhat peculiar construction has just been completed at the extensive works of Messrs. Fox, Henderson and Co., Smethwick, the following description of which may not be uninteresting to our readers:—The structure consists of a cast-iron tower, or hollow column, of a conical form, 70 feet high from high water to the top of the lantern; 12 ft. 6 in. diameter at the base, and 10 feet diameter at the top. It is composed of fifteen horizontal tiers of segmental plates, each tier 3 feet high, and so divided that no one plate exceeds 7 feet in breadth. The plates are provided with flanges, strengthened with brackets, and having bolt-holes with bosses opposite each other for bolting together. The thickness of the plates varies from 1½ to 1¾ inch. Round the bottom tier of plates there is a large flange, through which a number of long holding-down bolts pass to secure it to the foundation. In the second tier of plates there is a strong cast-iron door, accurately fitted, leading to the staircase, which winds round a central column. Equally distributed throughout the tower are six windows, to give light to the staircase. They are of a circular form, and the frames are made of cast-iron, secured to the plates, and glazed with plates of glass ¾ths of an inch thick. The entrance-door at the foot of the tower is 6 ft. 8 in. high, and 3 ft. 6 in. in width. The hinges are of brass, and fixed to the door and frame with countersunk headed tap-screws. The gallery platform at the summit of the tower, for the support of the lantern, consists of cast-iron radial plates, ¾ths of an inch thick, truly-pointed, fitted, and bolted together. The projectional portion of the platform rests upon eight cast-iron brackets, filled and fixed to the upper tier of segmental plates of the tower. The gallery platform is provided outside with a railing of wrought iron, 3 ft. 6 in. in height, consisting of baluster-rods, fitted to a rail at the top and bottom. The top of the spiral staircase is provided with a deal-boarded inclosure and a deal door, forming a bulk-head, to prevent any draught entering the lantern. The lantern is 10 feet in diameter over all, and 11 ft. 6 in. high from the floor of the gallery to the underside of the roof. The lower part, or plinth, is 4 ft. 6 in. high, and constructed entirely of cast-iron plates lined with wood. One-half of the lantern consists of cast-iron plates, lined with wood, and the other half is glazed with flat plate-glass fixed in gun-metal sash-frames, and fastened with putty and metal pins. The roof is composed of double plates of sheet copper. A copper ventilator and a dart weathercock is fixed to the top of the lantern, and a lightning-conductor, tipped with gold, has been added. The whole of the cast and wrought-iron is painted in oil colour, with the exception of the bolts and nuts, which are thoroughly coated with coal-tar. The lantern is provided with a reciprocal light illuminating 180° of the horizon, consisting of fourteen Argand lamps and fourteen plated reflectors of the most approved construction. The lantern is reached by ninety-eight steps of cast-iron. The lighthouse, on being completed, was, according to agreement, erected on the premises, and all the parts connected, and it is at present standing in its complete state on a rising ground near the canal. On two occasions the lantern has been lighted, and produced a wonderful effect—surpassing expectation—and at night was seen at an immense distance. The drawings, &c., were supplied by Mr. Cowper, the eminent engineer at the London Works. The lighthouse is for the East India Company, and its destination Middleton Point, Saurer Island, India.—*Birmingham Gazette*.

New York.—A new bank, called the Pacific Bank, has been built in Broadway. The well-known hotel, the Astor Hotel, is being repaired and enlarged. At no period was there ever such activity in building in New York, or such quantities of building materials brought into the city.

ON DEDUCTIONS FROM METEOROLOGICAL OBSERVATIONS.

On Deductions from Meteorological Observations. By JOHN DAWK, Esq., F.R.A.S., Member of the Council of the British Meteorological Society.

THE efforts of the British Meteorological Society are directed, for the present, to the attainment of mean monthly values of atmospheric phenomena for various localities. My last paper directed attention to the absolute necessity of referring all observations to acknowledged standards; and pointed out the means by which observers in districts widely dispersed, might be certain that the indications of their instruments were in accordance with truth. Presuming that the possessors of trustworthy instruments are competent to record their observations accurately and faithfully, it is my intention, in continuing the subject, to devote the present essay to the explanation of certain legitimate deductions from thermometric and barometric registrations.

To be able to compare the observations recorded in various quarters in a manner the most immediate and direct, it is of importance that the daily registration should be conducted by each observer on precisely the same plan; so that on the transmission of the series to head quarters, a comparison of column with column may be made at a glance. To facilitate this essential object, the Council of the British Meteorological Society, at its meeting in July, agreed upon a form of registration which has since been printed, and which may be obtained from Mr. Glasbier, the Honorary Secretary, by all those who are anxious to co-operate in the objects of the Society. Each sheet is ruled for one month; and the following copy of the heading will show the extent of the demand on an observer's industry:—

Month's Age.	Day of Week.	Day of Month.	At A.M., Local Time.					
			Reading of					
			Barometer	Attached Therm.	Dry Bulb Therm.	Wet Bulb Therm.	Wind.	
							Direction.	Force 0-4.

At A.M., Local Time.							
Reading of Self-Registering Thermometers.				Rain fallen in previous 24 hours.		Prevalent Direction.	Leading, Rud-dling, Flowering of Hardy Plants, Forest Trees, &c.; and Arrival and Departure of Migratory Birds.
Max. in Air.	Min. in Air.	Max. in Rays of Sun.	Min. on Ground.	On the ground.	Feet above ground.		

Notation used in General Remarks.				Occasional simultaneous Readings of Self-Registering Thermometers at Hours of Ordinary Observations.			
A. denotes aurora.		m. denotes mist.		Max.	Min.	Max. Sun.	Min. Grass.
cl.	clear.	ms.	mist.				
ci-cu.	cirro-cumulus.	ns.	nimbus.				
ci-s.	cirro-stratus.	r.	rain.				
cu.	cumulus.	s. r.	heavy rain.				
cu-s.	cumulo-stratus.	c. s. r.	continued do.				
d.	dew.	s.	stratus.				
f.	fog.	sc.	scud.				
fr.	frost.	sl.	sleet.				
h-fr.	hoar-frost.	sn.	snow.				
h.	haze.	so. h.	solar halo.				
h d.	heavy dew.	sq.	squall.				
ld.	hail.	sq.	squall.				
l.	lightning.	t.	thunder.				
li. cl.	light clouds.	ts.	thunder storm.				
li. sh.	light showers.	w.	wind.				
li. co.	light clouds.	g.	gale of wind.				
li. h.	heavy haze.						

Sum of the observations during the month			
Means .. .. .	..	..	..
Index errors .. .. .	..	..	..
Correction for Diurnal Range			
Means corrected .. .. .	..	..	..

From the adopted Mean Temperatures of Air and Evaporation, the following hygrometrical results are to be calculated by Glaisher's Hygrometrical Tables.

The Temperature of the Dew-point .. .. .	..	..	..	..
The Elastic Force of Vapour .. .. .	..	..	..	..
The weight of Vapour in a cubic foot of Air .. .. .	..	..	..	..
The additional weight of Vapour required to saturate a cubic foot of Air .. .. .	..	..	..	..
The degree of Humidity (complete saturation = 1) .. .. .	..	..	..	..
The average weight of a cubic foot of Air .. .. .	..	..	..	..

The original register, or a verified copy, is to be transmitted, at the end of every month, to the Secretary of the British Meteorological Society, 15, Dartmouth Terrace, Blackheath, Kent.

The atmosphere which surrounds our globe is subject to agitations far more extensive than the swell of the ocean; waves as broad as the Atlantic itself pass over us from time to time. Independently of these atmospheric waves, hourly variations in the pressure of the air have been determined, which seem to follow a definite law. One of the causes of these fluctuations is variation of temperature; another is the union with the aerial of an aqueous vapour. Such is the tendency of the air to unite with the vapour of water that it may be said, in no case, to be found in a state of absolute dryness: the supply is obtained from rivers, the ocean, the surface of the soil. The very laws of nature tend to its distribution—winds and atmospheric currents lead to its equable diffusion. We may, indeed, consider the globe to be surrounded with two co-existing atmospheres—the one of air, and the other of aqueous vapour—not chemically combined, but commingled, or mechanically united; the one being, as it were, diffused throughout the pores of the other, as water through the substance of a filtering vessel or the pores of sponge; and they may be, for the sake of experiment, as readily separated as the sponge may be relieved of its aqueous burden by compression. As the sponge, moreover, by its elasticity will recover its size, as before, so if we deprive a cubic foot of air of its moisture it will occupy the same space, though its density will be less. The experiments of Dalton and others have proved this remarkable fact, that under similar circumstances as to temperature and pressure, the quantity of watery vapour existing in air will be exactly equal to what it would be in a vacuum of equal capacity; and that, if we have the means of computing the pressure or weight of vapour in vacuo, we shall be able to determine with equal accuracy the actual weight of moisture in a given volume of air by the same means; in fact that, in either case, the pressure will be the same.

The capacity of air for moisture increases with the temperature; but there is a limit to its power of holding aqueous vapour in solution; when this limit is attained, the air is in a state of complete saturation. If from any cause a volume of air in this condition should be suddenly cooled, a deposition of moisture succeeds; the air parts with aqueous vapour in minute particles; and if it be free from agitation these appear in the form of dew, which is witnessed in perfection after the removal of the heat of the sun on a still autumnal night. The effect of a temperature below the freezing point will be to convert the dew into hoar frost, as is visible when winter approaches.

Should the air part from its moisture at a distance from the earth's surface, the aqueous particles will separately descend but slowly, or not at all. By the law of aggregation, they will unite in globular forms, and their united weight being now sufficient to overcome atmospheric resistance, they will be attracted towards the earth, and fall in the form of drops of rain. That electricity is concerned in the production of rain is more than probable; and this opinion is confirmed by the fact, that copious and heavy showers fall during a thunder-storm.

Dry air is denser than the vapour of water, and a mixture of the two will be lighter than the same volume of dry air alone. Thus we find the mercury of the barometer will indicate a decrease of pressure on a damp foggy day; whereas it will be found to rise in fair dry weather. Most of the variations indicated by the barometer arise from the greater or less degree of moisture existing in the air; and the interchange of aerial strata of various densities, and in various conditions as regards heat, produces all the fluctuations of pressure observed. Whether these are only the lower strata of the atmosphere—how high they extend—whether the height of the atmosphere above the earth's surface is invariable—are questions for science to determine.

Evaporation and condensation of aqueous vapour tend, in various ways, to diffuse heat more equally throughout the globe. As the power of the air to imbibe moisture increases with the temperature, evaporation goes on with most rapidity in warm climates, and the

heat absorbed in the process has a cooling tendency. Strata of warm air, elevated by the in-rush of cooler draughts, are driven to regions where the temperature is lower; here the vapour is condensed, and its latent heat is given forth to mitigate the severity of the colder climate.

If two saturated volumes of air of unequal temperature, and therefore of varying capacities for moisture, meet each other, their tendency will be to unite and equalise both the temperature and the moisture. The moisture, however, will always be in excess, for the two processes will not proceed at the same rate. Thus, supposing two volumes of air, one of the temperature of 40°, and the other of 60°, to unite, the mean temperature of the mass will be 50°. The elastic force of vapour at 40° of temperature (as will be explained more fully hereafter) is .264 measured as pressure in inches of mercury; at 60° it is .333; but at 50°, the mean of the two temperatures, the elastic force is .373, which is less than .334 (the mean of the others) by .021: this represents the tension of that portion of moisture which would be set free. If this vapour, in its liberated state, meet with a stratum of air not saturated with moisture, it will be re-absorbed either partially or entirely; if only partially, the remaining portion, consisting of aqueous vapour in an extremely minute state of subdivision, may be arrested in its descent, and float in the atmosphere in the form of clouds.

From the preceding observations it will appear that the pressure shown by the barometer is compounded of that of the air itself, and the co-existing vapour of water, from which it is never entirely disunited. It will now be shown in what manner these two forces may be separated, and the proper value assigned to each. We shall then be led to appreciate the simplicity of the process of deducing the hygrometric state of the atmosphere from simply observing the difference between dry and wet bulb thermometers; in other words, by remarking the difference between the temperature of the air and the temperature of evaporation.

Tension of Aqueous Vapour.

The experiments of Dalton, and more recently of Dr. Ure, Regnault, and others, have been the foundation of tables, showing the elastic force of vapour as measured in inches of mercury for every degree of temperature. Since many of the deduced results depend upon these, a description of the method employed by Dr. Ure in determining the tension of vapour may tend to give confidence in the results.

D L E is a syphon barometer, the leg E being closed, and the other open at D. On the admission of the mercury there will, of course, be an equilibrium when the column in the closed leg balances the atmospheric pressure on the surface of the mercury in the other, and the space above G will be a vacuum; a glass vessel is adapted to the outside of this portion of the tube, and rings of platinum wire on the exterior of the tube serve to mark the height of the mercury in each leg. A drop of water is now introduced into the vacant space above G, which is forthwith changed to vapour, and the vessel A is filled with water, the temperature of which is shown by the thermometer inserted therein. The tension of the vapour will of course cause the mercury to descend in the tube E, and rise in the tube D; a portion of the metal is now poured into the open tube until its weight counterbalances the tension of the aqueous vapour, and brings the mercury to its original level at G. Let O L be the space occupied by the additional quantity of mercury; this space, accurately ascertained, will be the measure, in inches of mercury, of the elasticity of aqueous vapour at the temperature shown by the immersed thermometer. By varying the heat of the water, by using freezing mixtures for the low temperatures, and boiling oil for the higher, Dr. Ure obtained results ranging between 34° and 312° of heat; the elastic force for the former being 0.17 inch, for the latter, 167 inches.

The Greenwich Meteorological Observations contain "A Table, showing the Elastic Force of Vapour in inches of Mercury for every tenth of a degree, from 0° to 90°;" an extract from it is here given, to illustrate its use in the subsequent deductions.

Temp. Fahr.	Force of vapour in inches.	Temp. Fahr.	Force of vapour in inches.
31	0.196	34	0.214
32	0.200	36	0.222
33	0.207	38	0.230

Temp. Fahr.	Force of vapour in inches.	Temp. Fahr.	Force of vapour in inches.
37	0.220	41	0.254
38	0.226	42	0.259
39	0.232	43	0.263
40	0.238	44	0.268

Dew-Point.

If a volume of air of the temperature of 35° be saturated with moisture, it follows that the tension of such moisture is equivalent to .222 of an inch of mercury. Hence, if the barometer reading be 29.886, the pressure due to air alone, supposing it to be deprived of its vapour, is 29.886 — 0.222; or, 29.664.

Complete saturation, however, is of comparatively rare occurrence; only, indeed, when the readings of the wet and dry bulb are alike. In every other case the air is capable of retaining a greater quantity of aqueous vapour. The knowledge of the dew-point here comes to our assistance. The dew-point gives a temperature to which, if we suppose any volume of air reduced, it would be saturated with the moisture contained within it. This point may be ascertained immediately by means of Daniell's hygrometer, as was shown in my last paper. Entering the table then with the temperature of the dew-point, or that temperature at which the air would be ready to part with its moisture, we ascertain, as before, the tension of aqueous vapour under any given condition of the atmosphere.

Thus, supposing that dew begins to be deposited at 31°, the air being of any temperature, we enter the table with 31°, and find the tension of aqueous vapour 0.192 inches; which, subtracted from the reading of the barometer, will give the pressure of dry air.

If the dew-point is not directly ascertained, it must be inferred from simultaneous observations of the dry and wet bulb thermometers, by means of Glaisher's factors, to be spoken of presently. In Mr. Glaisher's practice, he at times experienced difficulties in the use of Daniell's hygrometer; and at times he found that the simultaneous results of the dew-point, as found from Daniell's hygrometer and the dry and wet bulb thermometers, were discordant: and on investigating these causes, he found that the error rested alone with Daniell's hygrometer. The times at which these discordances existed were in those particular states of the air when great dryness was prevalent; and the depression of the temperature of the dew-point below that of the air was great, and a long time elapsed after the dropping of ether on the white ball before dew was deposited on the black ball. Such would require the long continuance of the observer near the instrument, and this necessarily would influence both the hygrometrical state, as well as the temperature of the air around the instrument; and this would be especially the case if the observer be short-sighted, and obliged to approach the instrument very nearly. And he makes the following objections to the use of this hygrometer:—

"Supposing the inclosed thermometer to be one of extreme delicacy, which it is not, it would then indicate the temperature of the portion of ether only in which its bulb was in contact, and which portion may be very different from that which is below it; and may be very different indeed from that part of the outside of the glass upon which the dew is deposited. And if the ether be dropped very slowly upon the white bulb, so that evaporation should proceed slowly, the evil of long-continued watching is required; and if more quickly, then the different layers of the inclosed ether is of different temperatures. It must also be recollected that the situation of the black ball, upon which the deposit of dew takes place, is not very far from the white ball; and in cases where large quantities of ether are necessary, such must influence materially the hygrometrical state of the air in the space included by both bulbs."

In consequence of these sources of error in the use of Daniell's hygrometer, together with its expense in use and trouble in using, Mr. Glaisher made many attempts, by different combinations of the results derived from the observations of the dry and wet bulb thermometers, to deduce the temperature of the dew-point from them; and at last found that the difference between the temperatures of air and dew-point, divided by the difference between the temperatures of air and evaporation, was constant at the same temperature; but that this value was different with every different temperature.

He then collected all the simultaneous observations which had been made at Greenwich, every two hours, from the year 1840 to 1844, and from them deduced the following table:—

Table of Factors, by which the Difference of Readings of the Dry Bulb and Wet Bulb is to be multiplied, in order to produce the Difference between the Readings of the Dry Bulb and Dew-Point Thermometers.

Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.	Reading of the Dry-Bulb Thermometer.	Factor.
37	5.6	39	5.1	41	4.6	43	4.1	45	3.6
38	5.5	40	5.0	42	4.5	44	4.0	46	3.5
39	5.4	41	4.9	43	4.4	45	3.9	47	3.4
40	5.3	42	4.8	44	4.3	46	3.8	48	3.3
41	5.2	43	4.7	45	4.2	47	3.7	49	3.2
42	5.1	44	4.6	46	4.1	48	3.6	50	3.1
43	5.0	45	4.5	47	4.0	49	3.5	51	3.0
44	4.9	46	4.4	48	3.9	50	3.4	52	2.9
45	4.8	47	4.3	49	3.8	51	3.3	53	2.8
46	4.7	48	4.2	50	3.7	52	3.2	54	2.7
47	4.6	49	4.1	51	3.6	53	3.1	55	2.6
48	4.5	50	4.0	52	3.5	54	3.0	56	2.5
49	4.4	51	3.9	53	3.4	55	2.9	57	2.4
50	4.3	52	3.8	54	3.3	56	2.8	58	2.3
51	4.2	53	3.7	55	3.2	57	2.7	59	2.2

On the Weight of Vapour in a Cubic Foot of Air.
On the Weight of a Cubic Foot of Air,
On the Amount of Vapour required for Complete Saturation.
On the Degree of Humidity of the Atmosphere.

It has been experimentally determined by M. Gay-Lussac, that air expands $\frac{1}{497}$ th part of its bulk for every addition of 1° of heat, inasmuch as it expands equally with equal increments of heat from the freezing to the boiling point, to the amount of $\frac{1}{497}$ of its bulk. Taking a cubic foot of dry air at a pressure of 30 inches, and a temperature of 32° as unity, a simple proportion will give the space it will occupy when subject to any given degree of temperature—say 44°.

Now, by the addition of 120°, we find the expansion $\frac{1}{497}$ of the volume (viz., from 32° to 152°); required the expansion for 44 — 32, or 12°.

120° : 12° :: $\frac{1}{497}$: $\frac{1}{41}$, so that the cubic foot of air becomes 1.025 ft.

From determinations of the weight of a mass of dry air under a pressure of 30 inches by Sir George Shuckburgh, Biot, and Thénard, it is inferred that a cubic foot of dry air, at 32°, under pressure of 30 inches, weighs 563 grains; whence we may determine its weight after expansion by heat (say, at a temperature of 44°), by the following proportion:—

1.025 feet : 1 foot :: 563 grains : 549.27 grains.

The next step is to ascertain the enlargement which a volume of dry air receives when saturated with vapour at any degree of temperature; but in the examples, 44° will be the degree assumed, and a cubic foot the volume.

If a cubic foot of dry air, of known elasticity, be mixed with a cubic foot of vapour, also of known elasticity, and if the mixture be compressed into the space of one cubic foot, the elasticity of the mixture will be the sum of the two elasticities of the air and vapour; or, if it be allowed to expand till its elasticity is equal to that of the unmixed air (suppose 30 inches), it will occupy a larger volume, in the proportion of the sum of the two elasticities to the elasticity of the air alone. Now, from the table, we know the elastic force of vapour for every degree of temperature; let it be required to find the space occupied by a mixture of a cubic foot of dry air and moisture at the temperature of 44°.

Tension of aqueous vapour at 44° = 0.304 inches

Tension of dry air

30

30.304 inches.

Then, $\frac{30.304}{30}$: 1 :: 1 c. f. : 1.01012 c. f., which is the space occupied by the mixture of the two aerial fluids.

The following formula will give the result in more general terms:—

Let p = the atmospheric pressure, as measured by the inches of mercury in the barometer.

E = the elasticity of vapour at a given temperature (measured in the same way.)

v = the bulk of a certain quantity of air, when dry, at the given temperature, and under the pressure p .

v' = the bulk of the same quantity of air when saturated with vapour at the same temperature, and under the same pressure p .

Then, since the elasticity varies inversely as the volume, the

temperature remaining the same, that portion of the elastic force p , which depends on the air alone, which occupies the space n' ,

$$\text{is } p \times \frac{n}{n'};$$

and this, together with E , must make up the atmospheric pressure.

$$\text{Or, } p = p \times \frac{n}{n'} + E;$$

$$\text{whence, } n' = \frac{n}{1 - \frac{E}{p}} = \frac{1}{1 - \frac{0.002083}{30}} = 1.01013, \text{ as before.}$$

In the Greenwich Meteorological Observations will be found a table calculated from this formula, for every degree, from 0° to 90° . From the introduction to the yearly volumes, the following formulae and explanations are extracted:—

"Gay-Lussac has determined by experiment, that vapours, so long as they remain in an ætiform state, expand by the increase of temperature, precisely as permanently elastic fluids, and that they suffer changes of volume proportional to the changes of pressure; and he has, as previously stated, determined that air expands $\frac{1}{273}$ of its bulk from 32° to 312° , and that its expansion is uniform between these points.

Therefore, if the weight of a cubic foot of vapour, under the pressure of 30 inches of mercury, and at the temperature of 32° , be called W , and the weight—expressed in the same denomination—of an equal volume of vapour at the temperature t , be called W' , and, if E be the elasticity of vapour at the temperature t , then (the expansion of dry air from 32° to 312° being 0.375, or being $\frac{1}{273}$ part, equals 0.002083 for each degree of temperature),

$$W' = \frac{1.375 \times W \times E}{30(1 + 0.002083 \times t - 32)}.$$

Now, Gay-Lussac has also determined that a cubic inch of vapour, at 32° , weighs 0.149178 grains under the pressure of 29.922 inches of mercury; and, consequently, a cubic foot of vapour, under the same circumstances, weighs $0.149178 \times 1728 = 257.776$ grains; and under a pressure of 30 inches, it weighs

$$\frac{30}{29.922} \times 257.776 \text{ grains} = 258.448 \text{ grains.}$$

Therefore, substituting this weight for W , the formula becomes

$$W' = \frac{1.375 \times 258.448 \times E}{30(1 + 0.002083 \times t - 32)};$$

and from this formula may be formed a table, showing the weight of a cubic foot of vapour in grains, under the pressure of 30 inches of mercury for any range of the thermometer.

The degree of humidity shows, on a natural scale, the condition of the air as regards moisture; complete saturation being represented by unity, and the air absolutely deprived of moisture by zero. The numbers are obtained by dividing the quantity of vapour which the air contained at the time of observation, by the quantity which it would contain if it were in a state of complete saturation."

From these principles, combined with an extension of the calculations which I have not thought fit to enter upon, Mr. Gladsher has formed his hygrometrical tables, entering which with simply the readings of the dry and wet bulb thermometer, we are enabled to obtain by inspection—

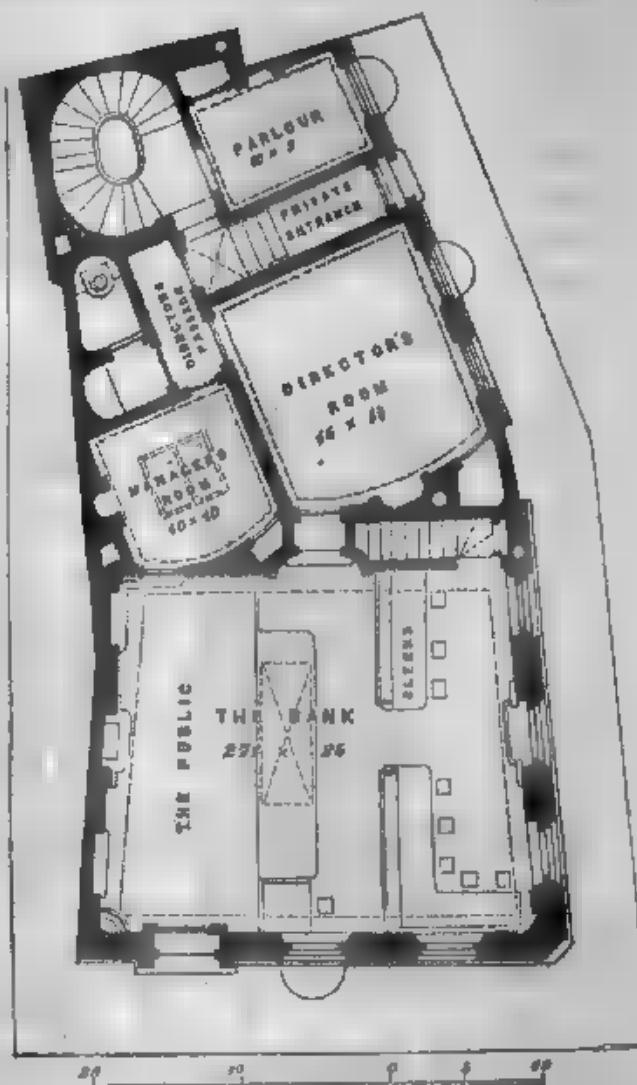
1. The temperature of the dew point.
2. The elastic force of vapour in inches of mercury.
3. The weight of vapour in a cubic foot of air.
4. The weight of vapour required for saturation of a cubic foot of air.
5. The degree of humidity.
6. The weight in grains of a cubic foot of air.

(To be continued.)

YORKSHIRE AGRICULTURAL & COMMERCIAL BANK.

We lately gave an engraving of a bank erected by Messrs. Atkinson, at Whithy; and in noticing another bank by them, we shall have occasion to make similar remarks. The bank now shown to our readers, is the office, at York, of the Yorkshire Agricultural and Commercial Banking Company. It is situated at the corner of High Ousegate and Castlegate, occupying an irregular plot of ground, but having a straight front towards High Ouse-

gate. The style adopted is Italian, with a good cornice, and with rustications on the base. The height is in three stories, with a basement, being altogether about 60 feet above the level of the pavement. On the Castlegate side, which is of some length, it has been necessary to make the building on two lines, receding from the main front.



PLAN OF GROUND FLOOR.

The ground-floor, which contains the banking offices, is of a height of 18 feet, and has an entrance, and two windows with circular heads. The material used is rubbed or cleaned Park-spring stone, rusticated in the quoins, and with a base rusticated in panels, and, except where interrupted by doorways, carried around the building. The first floor is 13 feet high, and has three windows in front, ornamented with mouldings, brackets, and carving. On the Castlegate side are six windows.

By the internal arrangements the whole front of the ground-floor is appropriated as the banking office, making a room 27 feet by 24 feet, and 18 feet high. Behind this are the manager's room, director's room, and manager's parlour. The banking office is highly enriched and well fitted. The windows have Bunnett and Corpe's iron revolving shutters. The basement is made fire-proof, and contains two fire-proof rooms. Into one of these works a large iron safe, like that described for the Whithy Bank. It is under the front counter in banking hours, and descends into the vault by an hydraulic pump. A wrought-iron door closes this vault when the safe is down. The safe contains all the cash-drawers, and was provided by Dewar and Co., at a cost of 2000. The cost of the building, exclusive of counters and furniture, was nearly 4000. The fire-proof vaults communicate with the bank above by a stair, and are shut off from the manager's private residence and offices.



BLACKFRIARS AND WESTMINSTER BRIDGES.

Two of the metropolitan bridges over the Thames—those of Westminster and Blackfriars—are giving way, and threaten destruction, in consequence of the sinking of some of the piers.

The ruin of these bridges will inevitably take place if some immediate and effective means be not employed to prevent it; and the consequence will be, a loss to the public of millions, a great inconvenience for many years to the thoroughfare between both sides of the Thames, and to the navigation in the river. Let us inquire what is the cause of that threatening disaster? The probability of such a result was foretold, and debated long before the removal of the old London Bridge. In 1786, Smeaton gave an opinion, that if the fall at London Bridge was reduced, the navigation above the bridge would be injured by a reduction in the depth of water; and that the transverse section of the bed of the river would be altered, and in many places lowered, in consequence of the increased current of the water. Time has shown, that in this his opinion was correct, but not so in that; because the navigation has been much improved by the removal of the old London Bridge, which impeded the uniform flow of the water in the river, and dammed it up, causing a fall under the bridge, dangerous to the passage of boats and barges, except at the time of high water. This damming up of the water had for result to keep the current nearly null on the bed of the river above the London Bridge, because the greater the transverse section of the water, the smaller in proportion will be the velocity required to transmit a given quantity of water in a given time. This reduction of the velocity, in place of excavating the bed of the river, allowed it rather to fill up by the accumulation of mud or fine sand drifted from the higher part of the river. But as soon as the obstacle to the water was removed by the removal of the old bridge, then, as was anticipated by all parties (I believe), the current on the bottom of the river was increased, the mud and fine sand were removed down the river, and during freshets the larger sand and gravel were also removed; and as the piers of the bridges diverted the current, especially at low water, into particular channels, leaving other parts opposite the piers dry, or with very little water and current thereon, the deeper these particular channels became the stronger the current would at all times thereafter be; and thus the transverse section of the river's bed has become deformed, by being successively and continually deepened between the piers. But this deepening between the piers caused an incline plane to be formed, from the piers towards the middle of the arch, or the centre of the excavation formed by the current; and the gravel (of which the bed of the river is chiefly composed in the London district) would naturally roll or slide down into the cavity of the channel, and be carried away with the current. This work going on during a succession of years, has, of course, reduced the level of the ground around the piers, and under some of them; the consequence is too apparent to be doubted, and if not speedily remedied, may be deplorable.

That Westminster Bridge, under the circumstance I have endeavoured to explain, should first show symptoms of dislocation, is what might naturally be expected, because the piers are founded on caissons only, without any piles to sustain them, whereas the piers of Blackfriars Bridge are founded also on caissons; but the bed of the river under these caissons is piled, perhaps not very deep; but the ground being piled, whether deeply or otherwise, should, and has, resisted during a longer time to the action of the currents, as above described. If any other proof than common sense and reflection were wanting for the accuracy of these deductions, it will be found in the circumstance, that during the construction of Westminster Bridge the bargemen had imprudently been allowed to remove gravel from near to one of the piers, so that the pier near to which the excavation was permitted, sunk as soon as the centres of the arches were removed, the 25th July, 1747, which accident caused the pier and two of the arches to be taken down and rebuilt, thereby preventing the bridge being opened for the public till the year 1750.

Blackfriars Bridge was not finished till 1770, being 20 years later than that of Westminster, so that even the benefit of the piles under the caissons does not appear to have enabled it to withstand the mining action of the currents on a gravel bottom. Neither will the Waterloo, the Southwark, or the new London Bridges be exempt from this casualty, if the foundations of the piers be not imbedded deep enough, beyond its influence, or that means be not taken to prevent the further progress of the action of the current on the bed of the river.

We may now inquire what are the means hitherto employed, or suggested to remedy the work of destruction now going on, already so effective on two bridges not yet one hundred years of age, while the age of similar structures elsewhere are meted by thousands of years!—the old London Bridge, with all its defects, had endured nine hundred years.

In regard to Westminster Bridge, which had no piling under the caisson, and under which the action of the current had formed a deep channel in the bed of the river, under several of its arches, on a level with, or lower than the bottom of, the caissons. It was determined to construct cofferdams round the several piers thus undermined, and then to drive piles all round the foundations, with the intention, no doubt, to keep the foundation from slipping, and to keep the soil or gravel from going from under the pier. But the remedy thus applied unfortunately only tended to increase the evil, inasmuch that, during the driving of the piles, the concussion given by the driving, as well as the grappings and anchors used for this purpose in that part of the river, would facilitate and urge the already too prone disposition of the soil or gravel to fall into the depth of the channel, and be carried off by the current. And every pile thus driven, besides causing the removal of a large quantity of gravel from under and around the piers within the sphere of its action, would also lessen the passage for the water, and consequently increase the velocity of the current, which would be thus progressively increased; and its action in the work of undermining the pier would also go on in a proportional progression, till the cofferdam could be completed, which is not the work of a day, of a week, or of a month, whereas the action of the current is incessant and loses no time, but will increase in energy as the pile-driving proceeds; and if, when the cofferdam is closed, putting the foundation of the pier in apparent security, the current then being contracted into a more narrow space, will, as if in retaliation, act with so much the more energy in deepening the channel, and thus tend the more to undermine the piers, and even the very piles which were driven for to baffle its efforts. That this is the result, has been fully shown, and will at all times, under similar circumstances, be so, is evident from numerous examples which could be cited, if it were necessary; but those who will not believe what they see, cannot be expected to take for granted what they are told. What I have here endeavoured to explain has, I believe, taken place at Westminster Bridge; during the time the piling was being proceeded with, the piers under that operation sunk so considerably as to endanger the falling of some of the arches. It was then decided to apply centerings to prop up the arches,—thus one expedient invariably leads to another. Let us examine for an instant the consequence which may be expected from this new expedient. I have already ventured to affirm that, after all the piling they have applied, and if as many more were added, it would not give stability to the piers, but, by contracting the water-way, would render the destruction of the bridge, if possible, more certain. If, then, under that dilemma, being certain the piers will continue to descend, while the arches are by centres retained at their present elevation and position, is it not evident that the pier will be separated from the arch, and thus the bridge would become completely dislocated, never again to be re-united until the pier be secure, and until the arch be rebuilt?

What is now going on at Blackfriars Bridge? They are tilting and tatting about the channel, under the bridge, and about the foundations of the piers, and after many weeks delay in searching out what might at once have been inferred, it has been discovered that the foundations of the piers are degraded, and the bridge consequently in a dangerous state; all this can be discovered by a superficial observer walking along the bridge, without either a diving-bell or a sounding-pole; the crushings and fractures, and variations of levels—taking place on the parapet from day to day, with a fearful rapidity—seem to announce the downfall of the bridge as near at hand, while nothing appears to be doing to prevent so deplorable a catastrophe, which, in case of the event taking place, will be anything but creditable to the country, and more especially to our engineering community.

It is in contemplation, say they, to stop the thoroughfare on the bridge, and to erect centres under the arches, as at Westminster Bridge; this will certainly be an interesting feature at the great Exhibition, to exhibit to the world, that after building costly, and what might well be deemed efficient bridges, that from unjustifiable parsimony, or neglect, we allow these bridges prematurely to perish! I have already said, and endeavoured to illustrate, what will be the result of piling and centering—it will aggravate the evil, and accelerate the destruction of the bridges to which it may be applied.—What then is to be done?

It is, in my humble opinion, simple, efficacious, expeditious, and of little cost, compared with other means that have been or may be suggested—that is, if not too late. For if the pier or piers of the Blackfriars Bridge be already very much degraded, there is no remedy but to demolish and rebuild the arches, and the pier or piers; but, if a few weeks ago (perhaps it is not yet too late), in place of wasting time in frivolous manoeuvres, those charged with these matters had set to work in right earnest, with every means available, to fill up with rubble stone or hard brick the deepest part of the channel under the bridge, to bring it up to the general level of the bed of the river at that part, the same operation being continued throughout the entire transverse section of the river, above and below the bridge, for at least one hundred feet; then, I have no hesitation in saying, the bridge would have been preserved from further accident. Having been so well forewarned of the probability of such accidents occurring, it appears to me unaccountable that the state of the bed of the river has not been carefully watched, more especially near the bridge, and that any deviation from the proper levels should not have been at once corrected, by filling in with stone or brick rubbish.

And if it be desirable to secure the other bridges from similar accidents, that which I have now suggested is the safest, the surest, the cheapest, perhaps the only rational mode of attaining the end desired—reason, and practice by the first masters, confirm what I here advance. Smeston employed this means to save the old London Bridge, in an emergency like that now occurring at Blackfriars Bridge, but he was imperative as to time, and by his desire the Corporation of London ordered a lot of houses to be pulled down, expressly to be thrown into the river: the bridge was at that time saved.

The engineer, Deschamps, having built a fine bridge of three or four arches over the Dordogne at Libourn in France. Before two years after its completion, the current had so lowered the bed of the river under the bridge, that the piles on which the piers are built were to a great extent laid bare, and the whole pier vibrated by the action of the current. To remedy the evil, he employed the means I have quoted, and succeeded. This incident led him to watch with particular attention another bridge of his construction, of nineteen arches, crossing a river 1600 feet wide (the Thames at London in, I think, 1200 only). Both these bridges of M. Deschamps's construction are built on a mud bottom, more than 60 feet deep. Notwithstanding this very precarious ground to build upon, his bridges have, by due attention, been preserved from injury, by employment of the means I have here suggested for the metropolitan bridges.

The examples I have cited are, I think, quite sufficient, in support of the explanation I have given in regard to the cause of such accident, and the means of preventing them. The remarks which have been made of late in several contemporary publications, on the state of the Blackfriars Bridge, have led me to the preceding considerations, which, with more leisure, might have been better arranged and more extended. The importance of the subject, nevertheless, however imperfectly here considered, will perhaps induce you, Mr. Editor, to receive, with your usual courtesy, these and any authentic information or well-intended suggestions on the subject.

London, Sept. 19th, 1850.

WILLIAM STEWART.

GOETHE ON THE CATHEDRAL OF STRASBURG.

[Translated by J. L.]

"The more I viewed the front of this edifice, the more my first impression was confirmed and developed, viz., that the sublime and the pleasing have been here completely blended. But as it is only possible to describe the impression made on us by that edifice, if we think of the combination of these two incompatible qualities, we become the more impressed with its great worth, and shall use every effort to express how such contradictory elements could ever harmoniously combine and penetrate each other.

Without considering at first the steeples, we shall speak of the front, which, in the shape of an erect oblong square, forcibly strikes our eyes. If we approach it at twilight, by moonshine, or in a stormy night, when the single parts have become gradually indistinct and have at last disappeared, we perceive nothing but a colossal wall, the proportions of whose breadth and height are adequate and pleasing. If we view it by daylight, and abstract in our mind from its details, we perceive the front of an edifice which does not only close up its interior, but even hides many adjacent parts. The apertures of this huge surface point to the

interior, its wants and contingencies—and according to this we may divide it into nine compartments. The great central porch, which is directed towards the nave of the edifice, first attracts our attention. On both sides are two minor ones, belonging to the aisles. Over the porch is the round window, which spreads over the church and its vaults a mysterious light. On the side of this appear two perpendicular large openings of an oblong square form, which bear a great contrast to the middle one, and seem to indicate that they belong to the base of the towering steeples. In the third story, three openings succeed each other, which serve for belfries and other ecclesiastical purposes. On the top the whole ends horizontally with the balustrade of the gallery, which serves in lieu of a cornice. The nine spaces just described are supported by four buttresses rising from the ground, which encompass them, and divide the front of the edifice into three large perpendicular sections. And as it cannot be denied, that the whole front possesses a fine proportion of breadth and height, these pillars also, as well as the gracile compartments between, add to the harmonious elegance of the detail.

But let us continue our abstractions, and fancy this whole wall without ornament and with solid buttresses, in it the needful apertures, but only so far as absolutely necessary; let us think all that in due proportion, then the whole would be still commanding and serious, but without appear cheerless and cumbersome, and be wanting in art and ornamentation. Because an object of art whose whole is comprised within grand, simple, and harmonious parts cannot fail to produce a noble and worthy impression; but that very enjoyment which is produced by the pleasing, cannot arise but from a concordance of all detail duly developed. And it is in this way that the edifice satisfies us in the utmost possible degree, because we perceive all and every ornament completely in accordance with that part which it adorns; they are co-ordinate to it, and seem to come out from it. Such a variety affords always a great satisfaction, as it is derived from a sense of appropriation (*aus dem Gehörigen*), and thence satisfies our propensities for unity; and it is only in such cases that the execution of a work attains the pinnacle of art—perfection.

By such means it has been effected that a compact wall, a solid surface, which we view also as the basis of two heaven-reaching steeples, appears to the eye, albeit independent of itself, existing for itself; still, as something light and gracile, something which although a thousandfold broken through, bears the stamp of indestructible solidity. Such riddle is most happily solved. The openings of the wall, the solid spaces, the buttresses, have each its own character, arising from its individual destination; this goes down gradually to the minor compartments—thence everything is ornamented in a chaste manner, the great and small is in its right place, can be understood with ease, and thus the pleasing is manifested even in the huge. I point merely at the doors, which are sunk perspectively in the substance of the walls, ornamented *ad infinitum* on their pilasters and pointed arches; to the window and that artificial rose-form which arises from its circular shape; in fine, the profile of its bars, as well as at the slender recumbent columns of the perpendicular compartments. May one fancy to himself the gradually receding pilasters, accompanied by slender, pointed arches; little structures, as it were, which, being destined for shrines of holy images, consist of equally uprising slender columns, ending in a sort of canopy; and thus, in fine, every frieze, moulding and finial is transformed into a cluster of flowers or bunch of leaves, or some other form of nature turned into the character of the rocky material. Every one may compare the building itself, or some designs of either the whole or its details, with what I have said, for the sake of judging and verifying my opinion. It might appear exaggerated, because I myself, although carried away at first by my admiration for this work, still required some time, until I became thoroughly imbued with its worth.

Brought up amongst cavillers at Gothic architecture, I cherished an aversion against those manifold, overloaded, confused, ornaments which, by their arbitrariness, rendered the character of a gloomy religion almost repulsive; and I became confirmed in this ill-will, as it were, merely works most deficient in spirit, on which neither a right proportion, nor any pure consequentiality was impressed, which came under my observation. In the Strasburg Cathedral, however, I thought to obtain a new revelation, as none of the above defects, but rather the reverse, were presented to me.

But the longer I continued to view and to consider, the merits above alluded to seemed to increase. I had already found out the right proportions of the major compartments, as sensible as rich an ornamentation, up to the minutest detail; now I began to comprehend the relation of these numerous ornaments to each other—the

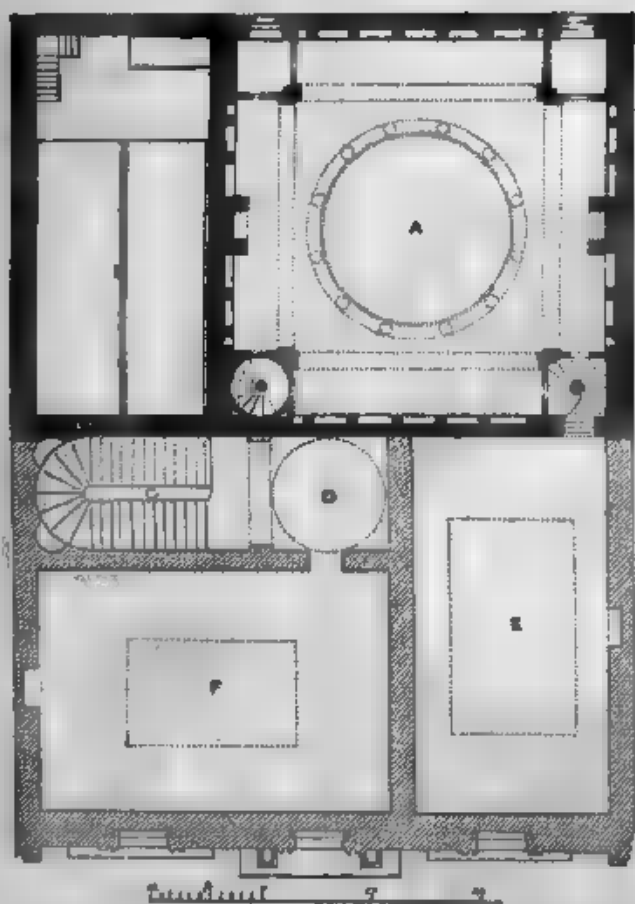
combination of so many single objects, although similar yet infinitely varying in form and particulars—from the saint to the monster—from the rose to the smallest leaflet. The more I observed, the more I found to admire; the more I mused, or wearied myself with drawing and measuring, the more I became enamoured of the work; so much so, that I devoted much time either in studying the present building, or in restoring on paper and in my mind, the much which is wanting and uncompleted, especially in the steeples.

And, as it was in an old German locality that I found this edifice reared, and in a truly German period of history so far progressed; and as the name of the builder on his modest cenotaph was also of German origin and sound, I dared, then, I say, called upon by the worth of the structure, to change the hitherto ill-famed appellation of Gothic architecture, and to vindicate the renown of German art-building for our nation."

THE PLYMOUTH PUBLIC AND COTTONIAN LIBRARY.

Messrs. Wightwick and Damout, Architects.

(With an Elevation and Plan.)



A, Library; B, Porter's Apartment; C, Staircase; D, Lobby; E, Law Library; F, Cottonian Library.

We give this month an elevation of the new building which is now being erected, in addition to the existing Public Library of Plymouth, for the reception of the munificent bequest which has been made by William Cotton, Esq., for the benefit of art and literature in the west of England; and certainly Plymouth has just reason to be proud of the good will of such a donor, and of the riches he has consigned to her possession. To meet the singular liberality of Mr. Cotton, the shareholders of the old library and the public in general have come forward in a manner which does them credit, to provide a fitting socket for the reception of the gems consigned to them: and a building has been designed, which,

though necessarily simple in its general form, will be highly ornate in its features. It is already commenced, and is expected to be finished about May next. The ground-floor will be devoted to the common entrance, and to the reading and committee-rooms of the Public Library; also to the staircase exclusively belonging to the Cottonian apartment, which will occupy the chief portion of the upper floor. Of this floor we give a plan. The rooms are to be lighted by handsome lantern lights, constructed with every regard to the due effect of the pictures, drawings, and articles of vertu which will enrich their walls.

The old building was erected in the year 1819, from designs by the late J. Foulston, architect, and presented a recessed front of severely Greek character, after the fashion of the Monument of Thrasylus at Athens. The present front is brought forward as far as permissible by the town authorities, and is in the Græco-Italian style. The architects are Messrs. Wightwick and Damout, of Plymouth, who have erected many public structures in the west of England, and the one now represented is not among the least creditable. The material is stone; and though the building is not of great dimensions, a character of respectability is given to it by the large size of the details, Messrs. Wightwick and Damout having carefully treated the door and windows, which are few in number, but of large size, well grouped together, and highly ornamented. On the ground-floor, it will be seen, these openings occupy much of the wall-space; and though decorated, the degree of ornament is less than on the first floor, where the three windows are each of single lights and smaller dimensions. These windows are carried up in the line of composition from the middle light of the lower windows and from the door, so as to secure harmony and uniformity in the design. The treatment of the cornice, balustrades, &c. likewise deserves notice, and contributes to the effect of the building. The various points of composition are well balanced; and the whole shows evidence of artistic skill and power of composition and combination.

Mr. Cotton's donation consists of various ranges of bookcases of ameyns wood, with plate glass fronts, containing many hundred volumes of books in the various branches of literature; a splendid and unique series of 4700 prints, engraved by the best artists from paintings by the most celebrated masters; a valuable collection of about 250 original drawings, by the old masters, in the most perfect state of preservation; a considerable number of paintings and framed drawings and engravings, of rarity and value; several illuminated MSS. of much beauty and elegance; some magnificent cinq-cento bronzes, terra-cottas, models in cork, and carvings in box wood, cabinets, carved furniture, &c.; many magnificent china vases and beakers, casts, &c.

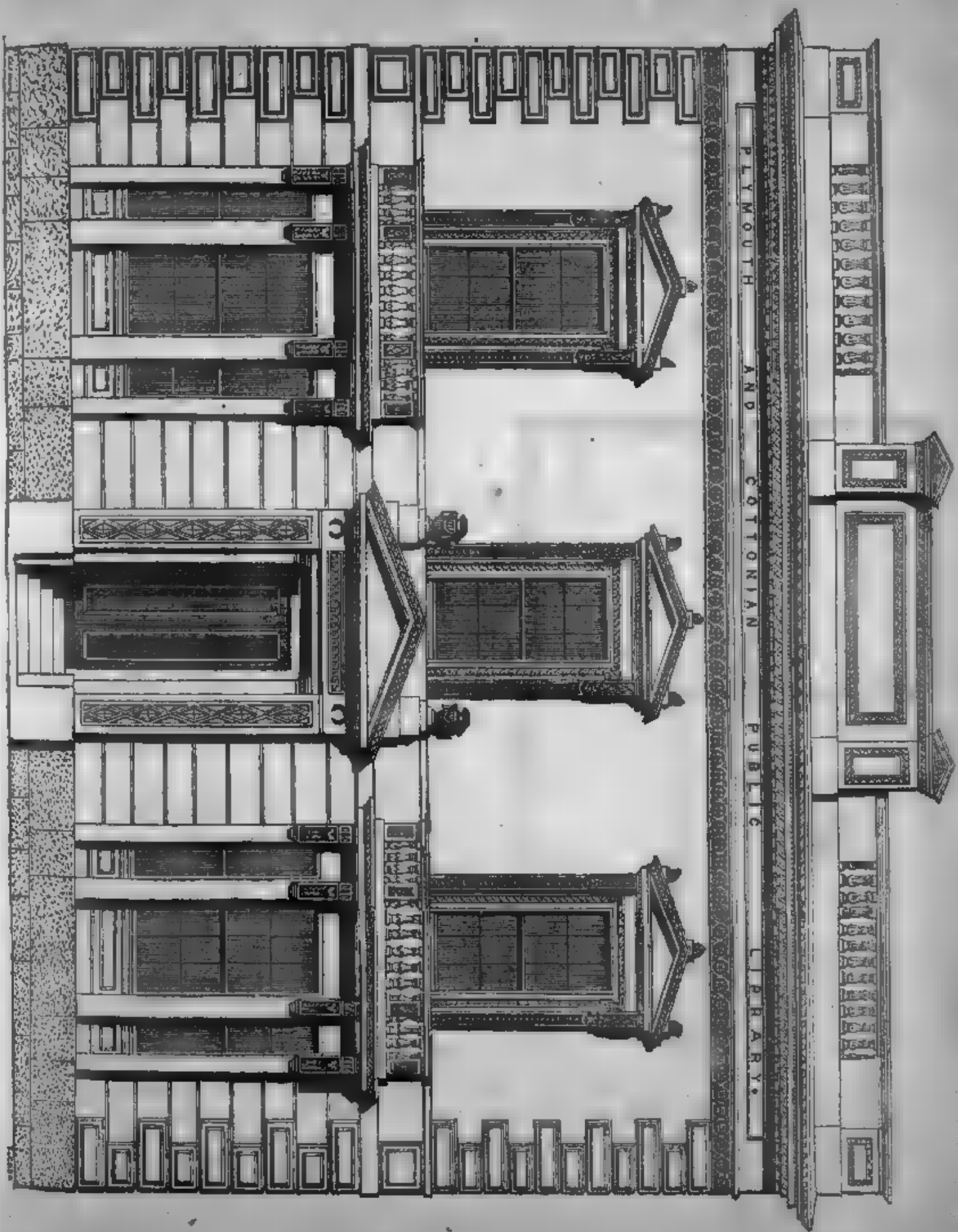
The collection of books contains many specimens of early Topography; works on the Fine Arts and Antiquities; Greek and Latin Classics; the most celebrated French, Italian, and Spanish authors; the English poets, &c.

The collection of original drawings by the old masters comprises amongst many others, some splendid examples by Zuccharelli, Guercino, Agostino Caracci, Claude, Ruysdael, Van der Walde, Berchem, Van Goyen, Van der Meer, Rousseau, Chateaubain, Breughel, Louthenburg, Domenichino, Carlo Maratti, Poussin, Boudon, Le Brun, Rubens, Vandyke, Verdier, Watteau, Cipriani, Ruyssch, Leonardo da Vinci, Andrea del Sarto, Bassano, Mola, Holbein, De la Bella, Callot, Boucher, Rembrandt, Inigo Jones, Barlowe, Seymour, Deacon, Worlidge, Richardson, Thornhill, Cosway, Paul Sandby, Watts, Marlow, Cattermole, Turner of Oxford, Denning, Purser, Wilson, Lambert, Wootton, Iman, Cooper, De la Motte, Dallaway, &c. &c. Among the bronzes are Lorenzo de Medici, after Michael Angelo; History and Eloquence, after Algardi; Samson and the Lion, by Benvenuto Cellini, (from the Pesaro Collection); Antinous, &c. &c.

Among the Models are a Philosopher reading, by Michael Ruyssch; Farnese Flora and Ceres, by Coado; Santa Sabina, by Bernini; Santa Susanna; Gladiator; Venus and Mercury, by Pigalli; Jupiter and Mercury, in wax, by Gosset; Shakespeare, Hindoo Idols, &c.; models of houses and baths at Pompeii, wood-carvings of Silenus, &c.

The paintings contain examples by Sir Joshua Reynolds, and many other distinguished masters.

Altogether this collection supplies great artistic resources for Plymouth and its neighbourhood, which boast the birth-places of Reynolds and Haydon. It is to be hoped application will be made to the government for a collection of casts, and that it will be answered with the same success as in the case of the Salford Museum and Library.



COMPETITION FOR THE BUILDING OF THE RHINE BRIDGE, NEAR COLOGNE.

THE above certainly is a work which, when completed, will reflect credit on our age, as since the times of DRUSUS no bridge ever existed on this part of the Rhine. The competition drawings went in amount to the large number of 163; amongst them 25 are from England. It cannot, however, be denied, that many of them are quite without any practical value. There are competent persons who also think that the small prize of 250 Frederic d'ors (of about 15s. each), may not have been sufficient for men of real ability to come forward in the competition. Still, amongst the plans from England, there may be several whose authors were rather prompted by ambitious motives than those of mere lucre. Some of the drawings attract notice by the splendid way in which they are ornamented. In a few cases there are special landscapes and views added to the plans, which could not have been drawn but by some professional painter of views. Some few are also framed and glazed, but the large size of the plans has occasioned their breaking during the transport. One of the competitors has specially come over to Germany, and has been presented to, and has dined with, the King of Prussia. It is, however, impossible to form now even an approximate idea, in how far this competition might have been the means to prepare the execution of a work whose estimated cost of one and a half million of thalers proves that even the mechanical means and contrivances of Germany will have to be strained for its ultimate completion.

L.

REVIEWS.

On the Strength of Materials, containing various original and useful formulae, specially applied to Tubular Bridges, Wrought-iron and Cast-iron Beams, &c. By THOMAS TATE, Author of the 'Principles of the Differential and Integral Calculus, Factorial Analysis, &c.' London: printed for Longman, 1850. 8vo., pp. 90.

When doctors disagree, who shall decide? Here is Mr. Tate asserting that the total breaking weight of the Conway Tubular Bridge is 2013 tons; while Mr. Hodgkinson computes the same quantity as low as 1084 tons—just about half!

Before inquiring which computation is nearest to the truth, let us explain that the difference of the methods by which such very different results have been arrived at is mainly this: Mr. Hodgkinson makes deductions from his own experiments, Mr. Tate from those of Mr. Fairbairn. The former found, from experiments on the direct longitudinal compression of wrought-iron tubes such as were to compose the cells of the top of the Conway Bridge, that eight tons per square inch was the utmost force which they could be relied upon to securely resist, and 12 tons per square inch to be their crushing force. He then assumes (Report of Iron Commission, p. 165) the material of which the bridge is made to be perfectly elastic; and when that is the case, the neutral line may be shown to be in the centre of gravity of the sections, the areas of the sections of tension and compression being inversely as the distances of the centres of gravity of those sections from the neutral line. He takes into account also the strength of the vertical sides of the bridge, of the angle-irons, &c. He finds the numerical values determining the position of the neutral line passing through the centre of gravity, and then shows that eight tons per square inch at the top of the tube (which he deems the limit of safety) corresponds to a load at the centre of the beam, which amounts, including its own weight, to 1084 tons, as above stated.

This is one method. The other likewise assumes that the elastic forces are proportional to the extension and compression respectively, and that the neutral axis coincides with a line passing through the centre of gravity of the section. Certain rules are laid down respecting the relative strength of beams similarly proportioned. (By the by, though Mr. Tate seems to imagine this method of treating the subject new, it has been employed in the pages of this *Journal*, and is also constantly referred to by Mr. Hodgkinson.) Then an experiment on the "model tube," of 80 feet long, in which the breaking weight was stated at 88.15 tons, is taken as the basis of calculation; and assuming the Conway Bridge to be similarly proportioned to the model, its strength is deduced to be 2013 tons.

Something is necessary to be said respecting the accuracy of this celebrated experiment on the "model tube." This tube was broken several times in succession by the rending of the bottom plates,

which were each time repaired, and increased in strength until at last the tube broke by crushing of its top. In the "Iron Commission" Report, p. 130, Mr. Hodgkinson gives the experiments in which the breaking weight was successively increased up to 66 tons, and there stops short, adding significantly, "There was a subsequent experiment on the same tube, which is not here given, as I conceive there must be some error in it." What error? Did Mr. Hodgkinson imagine that the breaking weight was erroneously set down? or that undue precaution was taken in selecting the very best iron, and so preparing the experiment, that its success was rather apparent than real? We are not informed for what reason this experiment is rejected; we are simply told that it is not trustworthy; and, considering what an important bearing this very experiment has on the whole question, and on the public safety, it is reasonable to complain that so grave a charge is not circumstantially supported.

It will be seen from the above account of Mr. Tate's method, that the accuracy of his calculation of the strength of the Conway Bridge depends ultimately on the accuracy of his results deduced from the data of the "model tube." On this subject he makes the following observations (p. 59):—

"In this model beam the principle of crumpling seems to be eliminated by the thickness given to the plates, by the combination of the cells, and by strong angle-iron used in connecting the plates. This is rendered apparent from the fact that the top area is nearly equal to the bottom one, when the equality to resistance is attained. Hence the model tubular beam may be regarded as a common beam, obeying the ordinary laws of compression and extension when subjected to transverse strain. The assumption, therefore, that the Conway Tube will have the same resistance to compression as the thin rectangular cells experimented upon by Mr. Hodgkinson is erroneous in principle; and this is rendered still more apparent from the calculations on the model tube given in Art. 65, where the resistance per square inch to compression is found to be about 19 tons, in the place of 8 tons, which Mr. Hodgkinson assigns to it."

The above method of establishing the original hypotheses respecting the law of elasticity is altogether inconclusive. Those hypotheses lead to a result which nearly accords with fact—namely, the approximate equality of the areas of the bottom and top of the tube when they are equally strong to resist tension and compression respectively. From this fact, Mr. Tate argues back that the hypothesis—not may—but must be true. The fact in question is, however, consistent with a thousand other hypotheses which might be contrived and combined so as to lead up to it. This mode of discussing the question is, in fact, the old illogical error of confounding a direct proposition with its converse—the inferring from "all mutton is meat," that all meat is mutton. T asks T, Do you admit so and so to be fact? Yes. Then my propositions are true, for they lead to it. This mode of discussion may be termed a *Tate-a-Tate*.

In order that the propositions may be certainly correct, every legitimate consequence of them must be consistent with correctly observed results. But, in truth, they lead to a result which, to any one moderately well acquainted with the laws of elasticity of iron, would instantly condemn them. In Art. 65, referred to in the above quotation, the tension per square inch of the bottom of the model tube is found to be 21 tons. Now, it is known, from frequent and indisputable experiment, that the elasticity of wrought-iron is almost entirely destroyed by a far less force. In the Report on Iron Structures, page 178, Mr. Hodgkinson states, that it appears "from the results of several experiments that wrought-iron strained by tension beyond 14 tons per square inch, or by compression beyond 12 tons per square inch, would be destroyed for all practical purposes."

It is difficult to ascertain the utmost extent to which wrought-iron can be stretched before breaking, because its ductility permits it to be drawn out almost to any degree—into a wire, in fact. Up to a strain of about 12 tons per square inch the extension increases almost precisely in proportion to the extending force. Beyond that strain the iron begins to be drawn out very rapidly. Consequently, the ratio of the weight to the extension is at first constant, but decreases very greatly after the strain exceeds the limit just indicated. For instance, in the Report of the Iron Commission, p. 47, the stretching weight (in pounds per square inch) of a wrought-iron bar 10 feet long, is found to be to the extension (in inches) in the mean ratio 23223 : 1, which ratio preserves nearly exact uniformity for the first 12 or 13 tons. For a single additional ton per square inch the ratio is reduced to less than one-half—namely, 113224 : 1, and one ton more reduces the ratio to 67363 : 1, which is between one-third and one-fourth the original value. When the strain is about

21 tons per square inch, its ratio to the extension is 16139:1, which is between one-fourteenth and one-fifteenth of the original value.

Mr. Tate assumes the extension to be always in the same constant ratio to the tension; and the latter he takes to be 21 tons per square inch at the bottom of the model tube. It appears, then, that he assumes the ratio at more than fourteen times its real value!

This is, of course, decisive of the character of his assumption as to "perfect elasticity." But the nature of the error may be even more palpably shown. If A be the distance from the neutral axis to the under edge of the beam, and a the ratio which the tension per square inch bears to the extension of a unit of length of metal, and p be the radius of curvature, we know, by the ordinary laws of simple beams, which Mr. Tate applies here, that the tension per square inch of the under side of the beam is

$$\frac{aA}{p}.$$

The quantity A Mr. Tate makes equal to 25.55, and the tension = 21 tons = 47040 lb. Also we have stated that the corresponding ratio of the tension to the extension of a bar 10 feet or 120 inches long, is 16139:1, consequently, $a = 16139 \times 120 = 1936680$. Therefore, the equation follows

$$47040 = \frac{25.55 \times 1936680}{p};$$

$$\text{or, } p = \frac{49489174}{47040}.$$

According to the hypotheses of the work before us, the constant moduli of extension and compression are different; but the equation to the curve of deflection will be of the same form as the ordinary elastic curve. Consequently, by known principles,

$$f = \frac{l^2}{12p},$$

where f is the central deflection and l the length of the beam between supports. Taking the value of p determined above, and $l = 75$ feet = 900 inches,

$$f = \frac{910000 \times 47040}{12 \times 49489174} = 64.1 \text{ inches.}$$

That is, the deflection is more than five feet four inches. Comparing this rather startling result with Mr. Fairbairn's statement to the Iron Commission of the observed deflection (which in the Report, p. 410, he says was 4.88 inches), we find that Mr. Tate's hypotheses make the deflection between thirteen and fourteen times the observed amount.

In addition to the above evidence, that the tension and compression of the lower and upper parts of the tube could not be what Mr. Tate calculates them to be, if the beam retained perfect elasticity, we have strong corroborative testimony of authorities on this very point. We have already quoted the opinion of Mr. Hodgkinson, that the metal would be destroyed by far less strain. Mr. Edwin Clark, also, in his evidence before the Iron Commission (Report, p. 361), observes:—

"We looked upon 12 tons to the inch to be as much as we could safely subject wrought-iron to as regards compression. We took the resistance to compression to wrought-iron as about 10 tons per square inch. We found, generally speaking, when you get up to 10 tons to the inch, most iron begins then to be perceptibly altered in shape."

Again, page 362, he says:—

"We were therefore limited to 12 tons to the inch, but as we were not going anywhere near such a limit as that, nor even half of it, it hardly came into play. If we made a thin coil it puckered; if we kept the same dimensions, and kept making the plates thicker, we avoided the puckering till at last we arrived at the thickness at which iron no longer puckers, but sustains nearly the whole strain of 12 tons per inch."

It was a matter of difficulty then, and of rare occurrence, to carry the strain up to 12 tons, whereas Mr. Tate computes it at one half as much more.

There is other evidence that the hypothesis of constant proportion of the elastic forces to the corresponding extension and compression is frequently quite remote from the truth. If the hypothesis were true, the deflection of all the experimental tubes should be proportional to the deflecting pressure. This, however, is found not to be the case. We here give a few of the deflecting weights, and corresponding deflections, of various rectangular tubes

experimented upon by Mr. Hodgkinson (Iron Commission Report, pp. 125 et seq.), together with what the deflection would be if proportional to the weight. All the columns of the following table, except the last, are taken from the Report.

Length of Tube.	Depth.	Breadth.	Weight on the tube in the middle.	Observed deflection.	Deflection if proportional to the weight.
ft. in.	in.	in.	lb.		
4 2½	3	1.95	448	.035	
			1344	.150	.105
			2240	.345	.175
			2464	.435	.1925
2 2	6	3.9	2136	.12	
			6616	.42	.37
			8296	.73	.46
			8856	.81	.49
31 6	24	15.5	11,369	.40	
			51,157	2.5	1.8
21 6	23.75	15.5	89,685	1.35	
			100,885	1.67	1.51
			120,485	2.59	1.91
			126,085	3.03	1.99
			128,885	3.48	1.94
31 6	23.75	15.75	53,685	.85	
			67,285	2	1.69
			72,885	2.25	1.83
31 6	24	16	20,532	.55	
			40,665	1.20	1.04
			50,730	1.66	1.30
			57,414	2.32	1.47

It appears manifest from a mere inspection of the preceding table, that Mr. Tate's assumption of the law of elasticity is not in accordance with a large number of observed facts. It is very important, however, to observe that whatever inaccuracies may be involved in the law assumed by him, are quite inadequate to explain the enormous discrepancy between the deflection of the model tube as observed and as computed. The discrepancy may arise in one of three ways—from inaccuracy of theory, from what Mr. Hodgkinson terms "some error" in the data of the experiment itself, or from combination of mistakes of both kinds. A very careful examination of the question has satisfied us that Mr. Hodgkinson's surmise is indisputably correct, and that the principal source of error is in the data of the experiment itself.

Without any doubtful assumption of the law of elasticity, we ascertain with sufficient accuracy the limits within which the tension at the bottom of the tube *certainly* must lie. We observe that the compression of the top of the tube is supplied partly by the plates forming its upper side, and partly by plates lower down. Consequently the "centre of compression" is somewhere below the top; similarly, the "centre of tension" is somewhere above the bottom. The moment of the "couple," of which the distance between these two centres is the arm, is equal to the moment of the pressure of the beam on its abutment or fulcrum. The greater the "arm" the less *ceteris paribus* are the equal forces of compression and tension. Therefore taking the arm equal to the whole depth of the beam, we make the tension less than it can possibly be. Supposing all the tension to be at the bottom of the tube, let t be the tension in tons per square inch. Take the area subject to this tension at 19 square inches, deducting 3½ inches, the area of the rivet holes. Also the depth of the tube is 54 inches, the moment of the tension is therefore $54 \times 19 \times t$. The pressure on the fulcrum is half 89.15 tons, the breaking weight, and the distance of the fulcrum is 430 inches. Therefore,

$$54 \times 19 \times t \text{ must be greater than } 89.15 \times 435,$$

or the tension must exceed 19½ tons per square inch; and Mr. Tate makes it 21 tons per square inch, a closely corresponding result. The result is not materially affected if we take into account the area of the vertical sides of the tube.

The deflection above computed is not that which would actually occur in a tube of the dimensions of the model strained to 21 tons per square inch on its under side; but merely the result of Mr. Tate's hypotheses. In the investigation of the ordinary elastic curve a certain quantity is neglected as small, which would not be

inconsiderable in the case before us. Also the expression for the radius of curvature is in reality dependent on the varying ratio of the tension to the extension. But that the *real* deflection of a tube of the given dimensions, subject to the given weight, would be much larger than the deflection given in the published accounts, appears certain from this consideration: the strain would be more than 184 tons at the centre; and it would be larger for a considerable distance on either side the centre; consequently, the extension of the material would be great, and therefore the radius of curvature small, for a large portion of the curve; whereas the published deflection would make the radius everywhere large.

As it appears then from the evidence of practical men, and also from the computation above, that it is quite impossible that the tube could sustain anything like the computed tension, we are driven to the conclusion that the data themselves are erroneous.

We refrain from comment on this most disagreeable conclusion, for the charge which it involves is of too serious a nature to be disposed of satisfactorily in an incidental manner. The public were indubitably called upon to place confidence in the sufficiency in the tubular bridges by the evidence of this very experiment, of which the particulars, it is but too evident, have been wrongly stated. We are anxious to believe that the exaggeration of the strength of the model tube was unintentional, that it did not arise from an ignorance of the power of mathematics to detect the fallacy, or a futile hope to escape that irresistible cross-examination.

Happily we have the investigation of Mr. Hodgkinson to give confidence as to the strength of the actual Conway tube. Mr. Tate objects that whereas in the tubular bridge the upper side of the tube is more compressed than their lower part, that investigation proceeds on deductions from experiments in the direct longitudinal compression of cells by a pressure uniformly distributed over their ends. But the weight of the objection is small when it is considered that the inequality of the pressure is small on account of the comparatively great distance of the neutral axis. The general character of Mr. Hodgkinson's investigation appears to be that of a careful and moderate estimate of the strength of the Conway Bridge, which, if the complexity of the subject do not permit of its perfect accuracy, is far, very far, more worthy of confidence than any deductions from the Millwall "model tube."

Useful Hints on Ventilation. By W. WALKER, Engineer.
Manchester: Parkes. 1850.

We are glad to see from the numerous and cheap works which issue from the press, that ventilation is attracting its fair share of public attention, and we therefore welcome the present contribution, as no doubt our readers will; and although ventilation is now supposed to be well enough understood, they will no doubt read with satisfaction the extracts we here give, illustrative of Mr. Walker's practical treatment of the subject.

In reference to steam agency Mr. Walker observes:—

"However useful steam agency, as applied to ventilating purposes, may be in factories or buildings connected with them, and in theatres or other places liable to great and sudden influx or efflux of persons; and well as it has been found to answer in its application to other buildings, such as club-houses, banks, collegiate institutions, and hospitals, in which manifest advantages have been derived from its employment; there will still be great numbers and many classes of edifices in which it would be, from various causes, inadmissible. Churches, chapels, and houses for worship, may be enumerated under this head—the numbers contained within their walls being, on the whole, tolerably constant, and not liable to very sudden fluctuations; but especially from the circumstance that they are seldom used more than two days in the week, with intervals of two or three days between; and when used it is only for two hours consecutively, with intervals of two or three hours between. With such proper quantity and sizes of ingress and egress flues as can readily be obtained in the thick walls and piers of such edifices (if planned prior to their construction), this short period of occupation will not permit their atmosphere to become very highly charged with impurities, while the intervals between the services will be found sufficient for an entire change of the whole atmosphere left in them at the close of each service, without resorting to mechanical means. In churches with lofty open roofs, of the mediæval or early-English construction, without galleries, the total cubic space bears so large a proportion to that portion of it occupied at the floor level by the congregation, that scarcely any injurious vitiation of the entire atmospheric contents can take

place during the short period of occupation, provided moderate preparations have been made for ingress and egress. Hence, very sudden and powerful ventilation is scarcely required in such churches, and the purification of their atmosphere may safely be left to the spontaneous action of those preparations; but on special occasions, and in hot weather, the action of the fresh-air flues may be accelerated by the exhausting power of a shaft or

trunk of adequate size running up within the tower or steeple, its upper end discharging into the external air, while its lower end communicates with the interior by openings in or near the roof; and this shaft may be made, in very hot weather, to perform two or three times its usual duty, by rarefaction produced at its lower end by a large number of gas burners fixed there in tolerably close proximity with each other, and supplied with gas from the mains which furnish light to the whole building. These ideas have been successfully car-

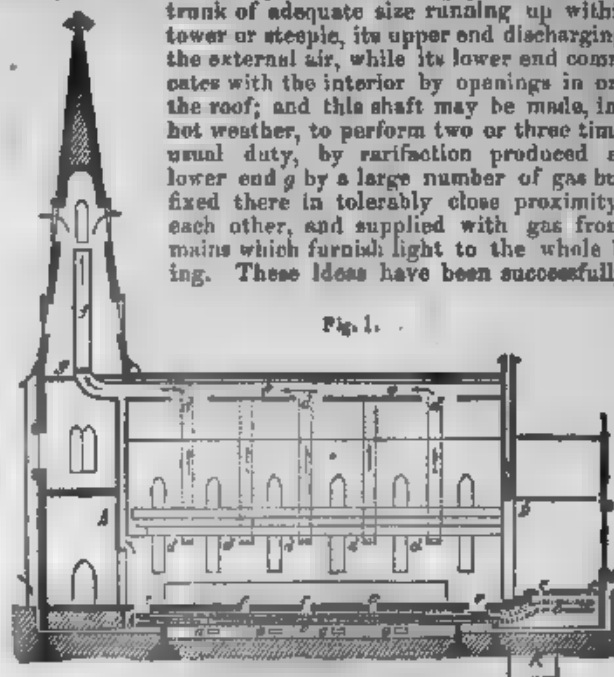


Fig. 1.

ried out in numerous instances and in large buildings. The whole process recommended for such a building will be better understood by a reference to the upper portion of figure 1, which represents a section of a church ventilated in this manner, a, a, are openings all round the church for admission of fresh air; b, b, hot-water pipes, over which it is made to pass on its way to the gratings c, c; d, d, are openings, by which the vitiated air enters a horizontal trunk e, from the end of which rises the shaft f, with a collection g, of gas-jets in the bottom of it; h, i, is the gallery-line, and k, an excavated room for the boiler, the floor of which should be five feet below the floor-line of the church.

"By simply turning the cock in the gas pipe which supplies the jets, the rarefaction in the shaft, and, consequently, the velocity and quantity of the air passed through the church, may be controlled with tolerable accuracy, and instantly proportioned to any greater or smaller number of persons assembled. The cost of piping and cock for bringing the gas to the jets has been found to be but trifling; and as they need only be lighted during the time the church is occupied for worship, which is seldom of longer duration than two hours and a-half, the consumption of gas is not very great, and amply compensated by the beneficial result obtained.

"The means most proper to be adopted for the plentiful supply of fresh air in the low-roofed, galleried, and crowded meeting-house, will be found to consist in abundance of fresh-air openings all round under the windows, communicating by brick flues with the lower part of the spaces under the aisles and seats in which the hot-water pipes that are to warm the air should be fixed. Fresh-air flues should be constructed in all the piers between the windows, running as high as the gallery to supply it with fresh warmed air. A vitiated air-flue should also commence in each pier under the gallery (in order to give free egress to that which would otherwise be intercepted and detained under the gallery), and pass up into a horizontal trunk, running over the roof, along each side, into the foot of the upright shaft below the gas-jets, as before explained. Openings should also be left in the roof, communicating with these horizontal trunks, to carry off the bad and heated air over the galleries. Hot water pipes should be conveyed along the side-walls, under the floor, so as to warm the air that passes up within the piers into the gallery.

"The leading points to be observed in such a case are delineated in the lower part of fig. 1, below the line h, i.

"A much larger provision should be made for supplying fresh air

to such a house for worship, or other galleried building, than in one which has no gallery, and which possesses the advantage of an open roof; and those who would object to the copious measures here recommended, as unnecessary, should well consider the following facts and calculations. A chapel or meeting-house with large galleries nearly all round, capable of accommodating on special occasions 2000 persons, is frequently made about 75 feet square, and 25 feet average height, giving a total cubic content of rather more than 140,000 feet. Now the authorities, from Tredgold to Reid who have written on the subject of the quantity of fresh air, required per minute by each individual, to replace that which such individual has rendered unfit for respiration, vary in their conclusions from $3\frac{1}{2}$ to 10 cubic feet; and if seven cubic feet be assumed to be the proper quantity, an allowance near the average of their scientific opinions will be given. The total quantity required, therefore, on this low standard in such a building, to maintain its atmosphere in a state of purity when filled, will be $(2000 \times 7 =) 14,000$ cubic feet every minute, and a like quantity of vitiated air must be carried off in the same time. The atmosphere of the building will therefore require to be completely changed or renewed $(140,000 \div 14,000 = 10)$ once in every ten minutes. Let it now be supposed that the unusual provision of 16 openings has been made all round the building, for fresh air, each opening measuring 18 inches by 8 inches. Deducting one-third of the area for impediment caused by gratings, will allow to each opening a clear area of

half a superficial foot, and the aggregate area of all the openings will be eight feet. Now, to supply the required quantity of air (14,000 cubic feet) in the given time (one minute) through those openings, the air must pass through them all at the velocity of $(14,000 \div 8 =) 1750$ feet per minute, or more than twenty miles per hour; which it will not do, especially on a calm day in hot weather, when ventilation is most needed, without the aid of some powerful stimulus; and if such artificial impulse be wanting, those openings will, under the circumstances, be quite insufficient to prevent the rapid deterioration of the atmosphere within, and ought, therefore, to be considerably enlarged. The bad effects of the usual way of obtaining a partial supply of air in such a case by opening the windows, have been already commented on.

"Take another example from a large Gothic church, with galleries, and lofty side aisles and nave, in the neighbourhood where this is written; measuring 80 feet by 65 feet, with a roof approaching to flatness, about 30 feet in average height. This church has often contained 1800 persons; its cubic contents being 156,000 feet, and the requirement of air, allowing, as before, seven feet per minute to each person $(1800 \times 7 =) 12,600$ feet. The time in which the whole atmosphere of this church would, when containing its full complement of persons, require to be changed, is $(156,000 \div 12,600 =) 12\frac{1}{2}$ minutes; and large openings will obviously be required to pass the quantity in the time.

"These figures will suffice to show the necessity for a very much larger provision for ventilation than has been customary in buildings containing galleries, in which the cubic contents bear a small proportion to the numbers assembled."

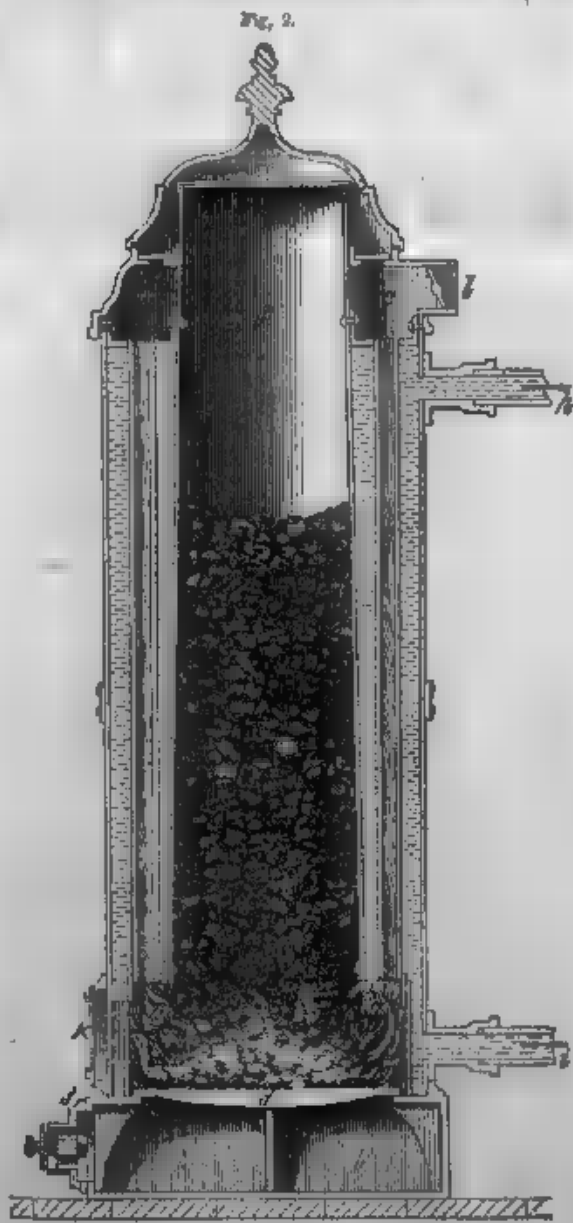
"The management of the warming of a church being a matter frequently entrusted to a sexton or vergier charged with other duties, which necessitate his making a clean appearance, and demand his exclusive attention during the service, it is a matter of some importance where hot-water apparatus are used, to adopt such form of boiler as will require the smallest possible attention. The kind shown in fig. 2 in the annexed section, will be found to fulfil this requirement; many large churches having been kept by it at a uniform temperature with only three attendances in twenty-four hours. This sort of boiler will be found very desirable in many other buildings besides churches. They are to be filled to the top with coke broken into small pieces, which falls on the fire as required. A very useful kind of Arnott stove has been largely adopted on the same principle."

The stove here described appears to us a very simple arrangement for effecting the purposes desired, and to be well worthy of adoption.

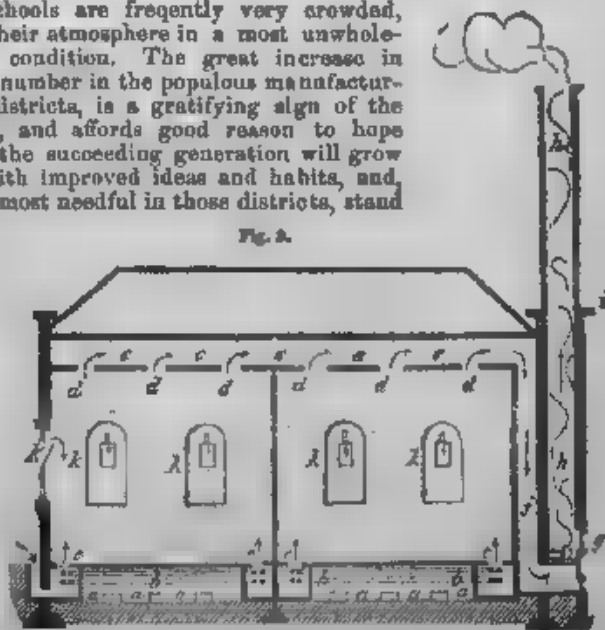
In the whole range of ventilation there is, perhaps, nothing so much neglected as the ventilation of schools; and as it is most desirable public attention should be turned to the subject, we most willingly give room to Mr. Walker's statement of his views on the subject:—

"Schools are frequently very crowded, and their atmosphere in a most unwholesome condition. The great increase in their number in the populous manufacturing districts, is a gratifying sign of the times, and affords good reason to hope that the succeeding generation will grow up with improved ideas and habits, and, as is most needful in those districts, stand

Fig. 2.



a, Fire-box; b, Ash-box; c, Smoke-box; d, Fire-bars; e, Smoke-tubes; f, Fuel-box; g, Damper; h, Flow or steam-pipe; i, Return or condensation pipe; j, Ash-box door; k, Fire-door; l, Smoke-pipe.



some degree higher than their predecessors in the scale of civilization.

"Fig. 3 is a section representing a boys' and girls' school ventilated (except as regards the windows) in a satisfactory manner; *a a* are the fresh-air openings; *b b*, pipes for heating; *c c*, gratings for entrance of fresh warmed air; *d d*, openings for foul air, leading into a trunk *e*, whence it is drawn down the shaft *f* by the rarifying-furnace *g*, whence it is discharged up the shaft *h* into the atmosphere.

"This arrangement of a rarified shaft, continued down to the ground for the purpose of obtaining a quick draught by a heated column, and requiring a down shaft to connect the ventilating trunk, from the top of the building, with its lower end, so that the foul air may enter it below the fire, is the same that has been adopted, at very great cost, by Dr. Reid, in the new Houses of Parliament. There is a complexity and expense about this arrangement which would seem to be needless. The drawing down to the ground-level of the whole of the vitiated air of the building, and then sending it up again; the cost of connecting the main down-shaft with the up-shaft, which circumstances may require to be at a considerable distance; and the trouble of forming air-tight connecting-flues to convey the vitiated air from numerous rooms to one main down-shaft, to say nothing of the double space and materials occupied by the two shafts, would render this plan, in numerous cases, impracticable. To overcome some of these difficulties, the fire has, in many cases, been provided for at the roof-level (i fig. 3), thus relinquishing the down-shaft and the lower part of the up-shaft, and so far has been an improvement; but in many cases the trouble of carrying up fuel and ascending to attend to the fire was too great, and the ventilation was, therefore, uncertain. The best mode of effecting forcible ventilation by a shaft doubtless is, to adopt the last-named arrangement; substituting gas-riflers for a furnace, as shown in the church. (Fig. 1.) By bringing the pipe which supplies gas to the burners to some accessible point near the ground-floor, with a stop-cock at that point, the handle of which should work in a graduated quadrant, the ventilation can be regulated from below with great precision.

"Window-ventilation of a kind very frequently adopted in churches and schools, has been introduced into this figure (i fig. 3), not with a view to represent it as part of Dr. Reid's system, but to illustrate its bad effects, either where it is the sole provision made, or where it is used in combination with a better process. If it be the sole provision made, and the room be heated by a fireplace or stove, to 60°, a downward rush of air at 10° (should that low temperature happen to prevail outside at the time), will play upon the heads of those near it. If it be in force, as in the figure, simultaneously with proper means of introducing fresh warmed air, its force will be modified, and partially deflected upwards, towards the egress openings; but whatever cold air thus enters, is so much deducted from that which ought to have entered warmed, through the proper channel *c*."

We may observe, that Mr. Walker has been largely engaged at Manchester in the construction and adaptation of stoves, and that he has had considerable experience in many practical applications of ventilation.

Suggestions for a New Street through the City of London, with a leading Aqueduct Sewer. By NATHANIEL BEARDMORE, M. Inst. C.E. London: Weale, 1850.

Mr. Beardmore proposes a very extensive system of street improvement and drainage. One part of his plan is to do away with Westminster and Charing-cross Bridges, and to construct a grand bridge leading from Charing-cross to the Waterloo-road. Another part is a street from Temple Bar, across Bridewell, south of St. Paul's Churchyard into Eastcheap, and thence by Crutchedfriars and Great Aile-street to the Commercial-road. Coupled with this, he proposes to carry a grand sewer through the metropolis, from Bayswater to Barking Creek.

Royal Agricultural Society's Prize Model Cottages. By HENRY GODDARD. London: Dean.

Mr. Goddard, an architect of Lincoln, gained the first prize for model cottages offered by the Royal Agricultural Society of England, and we presume that his designs were the best of those presented for competition; but we must say we have seen many designs which are more picturesque, and with better arrangements.

ON COOLING THE ATMOSPHERE OF ROOMS.

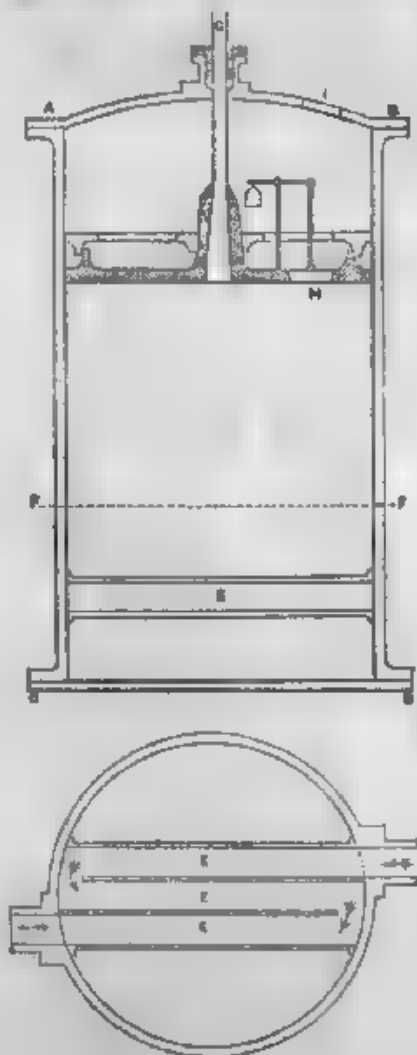
Sir—I was very much pleased with the description given in your last number, of the very ingenious and simple machine for cooling the atmosphere of rooms. Among the many excellencies of the apparatus, not the least, I think, is the similarity between the means employed in it and the operations of nature constantly producing similar effects—I mean the change of temperature by change of density. It is, indeed, an extraordinary thought, that the changes of temperature observed at different heights in our atmosphere may be accounted for by the fact of rarified air having a capacity for heat, increasing with its rarification, and that the same air which, made dense by the pressure of the atmosphere, feels so warm at the surface of the ground, may, wafted to some hill top, and thus freed from some part of the pressure, become the cooling breeze; and anon, mounting still higher, may take its place among the regions of eternal snow. It appears to me that the similarity existing between the means employed in the apparatus, and this process in nature, forms the very best guarantee of its effecting the object desired in the most suitable manner, as the parallel between the two operations exists throughout.

It appears to me, however, that some explanation of the cause of the increase of the temperature of air on compression would render the account of the apparatus more intelligible to the general reader, as it might create misunderstanding on the subject merely to say that air increases in temperature on compression, and diminishes on expansion; the fact being, that on compression the same quantity of heat exists in the air as did before compression; but this increase of density diminishing its specific heat (i. e. the quantity of heat required to keep it at its former temperature), the amount of heat it possesses above this must make itself sensible, and raise the air to a higher temperature; while, on the other hand, when by being rarified, or being allowed to expand itself in a larger space, its specific heat being increased, the quantity it possesses is unable to maintain its temperature, and it consequently is diminished, though neither change of temperature is in the same ratio as the compression or expansion.

I should scarcely think it possible that the objection anticipated by the inventor—viz., that the cooled air would be found unpleasantly moist, could occur. For, supposing the air to be lowered to the required temperature, it would be able to hold in suspension an amount of moisture in accordance with its temperature; and, of course, any attempt at condensation of moisture must be made by removing some portion of the heat of the vapour. As Dr. Lardner, in his 'Treatise on Heat,' observes (in speaking of the liquefaction of vapour by compression), that without an actual loss of heat having been sustained by the vapour, it would be impossible to imagine the condensation of any portion of the vapour into a liquid, as such condensation must be effected by the subtraction of all the latent heat which maintained the liquid in a vaporous form. But should it be found desirable to lower the temperature of the air more than could be effected (with air subjected to the amount of pressure stated as that best adapted to the purpose) by water of the temperature of 100°, or should it be found impossible to procure water of so low a temperature, I should think (as mechanical power must be used for condensing the air) that the mere evaporation of such water as can be procured—effected as described below, in a space approaching to a perfect vacuum in proportion to the degree of cold required, the vapour arising from the water being constantly removed, in order that its tension might not prevent the further evaporation of the liquid—would amply serve the purpose intended.

This effect might be obtained in the manner shown in the accompanying sketch, where A, B, C, D, is a cylinder, with openings at the sides to connect the pipes containing the air with the air chamber in the cylinder by spigot-and-faucet-joints. Water is to be placed in the cylinder, so as completely to cover the air chamber E, E, E, as shown by the level F, F. In the cylinder, a piston G works. This might be made perfectly air-tight with ordinary hemp packing, the upper plate of the piston being merely provided for the purpose of screwing down the hemp as might be found necessary, and being formed with large openings in it, as shown in the section; while in the lower plate a valve H, is placed, which might be loaded in a proportion relative to the tension of the vapour to be raised from the water. Thus, supposing the required temperature of the water to be 30°. The tension of the vapour of water at 30° is 0.375 of an inch of mercury; and as the amount of the pressure of the atmosphere (15lb. on the square inch) is equivalent to 30 inches of mercury, it follows that the tension of the vapour of water at 30° is equal to an 80th part of the weight

of the atmosphere, which is equal to about three ounces. Now the valve in the piston being loaded in this proportion to its superficies—that is, with a weight of nine ounces—if its superficies is three inches, and so on, it follows, that in the stroke of the piston the valve H would not be affected till the tension of the vapour became of the amount required, and, consequently, would not affect the temperature of the water till it was desirable to do so; and as the valve could be easily loaded with any weight, this would make the apparatus self-acting. The valve I, on the top of the cylinder, might be exactly balanced, so that there would be almost no pressure on the piston from the tension of the vapour above it: some lime also placed in a vessel on the piston would absorb the moisture remaining above it. The rapidity with which water loses its temperature in the exhausted receiver of an air-pump, shows that a few strokes of the piston would absorb enough of the heat of the water to lower it to the required temperature.



In the removal of the vitiated air, I cannot however but think that mechanical means would be far preferable to the mere opening of a sash, as this proceeding must cause a communication with the external air which would be far from desirable. And this circumstance at once brings under consideration the vexed subject of ventilation; that science so well understood in theory, but so lamentably displayed in practice, but which is at the same time a subject of so much importance, that I cannot refrain from quoting the words of a well known writer on this and similar topics. In contending for the superiority of ventilation effected by mechanical means, Dr. Arnott, in his 'Treatise on Warming and Ventilating,' observes, "It is a remarkable fact that the first accomplishment of perfect ventilation for a crowded place was not, as might have been anticipated, in the houses of the great and learned, and therefore in our houses of parliament or in the churches of the wealthy, or in fashionable assembly rooms of any kind—but in the cotton factories. In the first mentioned places it is true that openings were made in the ceilings and side walls, and cowls were placed over the openings or fires, or strong lamps were placed

within them to rarify the air and cause it to ascend; but as in all these cases, the important object was trusted to the working of invisible draughts or currents which might not take place, and which very often, from unsuspected countervailing influences, did not take place aright, the object was most imperfectly accomplished. It was in the cotton-factories that fan-wheels were first set in motion, which, with a certain speed of revolution, were known to extract a certain quantity of air."—In this paragraph the merits of the respective methods are fairly stated, and the plan is also mentioned as simple, and certainly as effective as could be desired.

In conclusion, I think that our best thanks are due to the ingenious and talented author of the apparatus under consideration for his very useful invention; the resemblance of the means employed, with the circumstance which, as he observes, is so often stumbled on by workmen, and is noticed in every work on natural philosophy, proves to us how long a principle may be patent to our senses ere our minds are struck by its applicability to purposes of general usefulness.

I am, &c.

Q.

THE ROUTE TO CALIFORNIA BY THE TEHUANTEPEC ISTHMUS.

Mr. Larosca, the American Minister at Mexico, it has been announced, has succeeded in effecting a treaty with the government of that country with respect to the Tehuantepec route across the Isthmus. It is understood that this treaty is similar in its character and conditions to that recently made by our efficient chargé d'affaires, Mr. Squires, between our government and that of Nicaragua. The documents connected with the affair will soon be placed before the senate of the United States. The presumption is, that the stipulations do not vary widely from those incorporated in Santa Anna's decree of the 1st of March, 1842; and in that of Mariano de Salas, dated the 5th of November, 1846. The former decree contained eleven articles, and the third of the series declared that the passage across the Isthmus should be neutral and common to all nations at peace with Mexico. The government generally made this whole decree, upon certain terms, with Don Jose de Garry, who it appears, has surrendered in some way all the concessions originally made to him to certain citizens of the United States residing at New Orleans. By way of distinction, therefore, this may be termed a New Orleans enterprise, though the results may be of national importance. The treaty was made on the 24th of last month, and it is calculated to call forth much discussion, as well as to excite great interest in every part of the country.

For many years the idea of making an easy route, either by railroad or canal between the Pacific and Atlantic Oceans, has not only arrested the attention of our countrymen, but the anxious inquiry of several European governments. A ship railroad, with a capital of 10,000,000 sterling, was proposed at one time in London, with a view of levying tolls upon all the nations of the earth. This was a gigantic scheme. When the mind contemplates the possibility of taking a ship into a dry dock on the Atlantic shore, of cradling it upon a car with 48 wheels, running upon eight rails, of seeing it transported across the country, and deposited in a dock upon the Pacific, the ingenuity of man becomes an object of admiration. We are startled with its boldness, though we can scarcely doubt the rationality of its resources. Vast capital can accomplish vast results. However, the English plan will not be carried into effect in the present century. The French and the Germans have made several surveys of different routes, as well as the English and Americans. That by Tehuantepec may or may not be practicable. Señor Gastano Moro's survey gives a highly favourable picture of the country for the proposed road. From his surveys, it seems that the entire distance from sea to sea is 135 miles in a right line. It presents a wide plain from the mouth of the Coatzacoalcas to the foot of the Mesa de Tarifa, which is a table-land rising to 850 feet above the level of the sea, and at five miles distance descends again to the plain which reaches the Pacific. Near Tehuantepec, Moro found two extensive lakes, the outer separated by a narrow sandbank from the ocean, and the inner and larger communicating with it by a channel between high banks. Eight rivers flow into them, and, with some improving, ships may find harbours in these waters. From the inner lake the land rises very gradually to the Venta de Chicapa, thence with a steeper acclivity upon Tarifa,—and there is a slight declivity to a river, which is navigable for ships for the distance of 24 miles from its mouth on the Gulf of Mexico. Such are the rude outlines of Moro's survey.

The resources of the country are immense for timber of the best quality for building a road. The facilities for cattle-feeding are complete. The soil is prolific, and salt mines are abundant. The climate is agreeable and mild, and usually salubrious. The advantages, therefore, for constructing a road cannot be overlooked. In a commercial and political point of view, however, such a road would be very desirable; and, could it be made, would add largely to the prosperity of our country. From the mouth of the Mississippi to San Francisco, by Tehuantepec, is 1825 miles nearer than by Panama. From New York 1490 miles of sea navigation would be saved, were this route opened,

THE VICTORIA REGIA HOUSE, CHATSWORTH.

We are indebted to the *Gardeners' Chronicle* for the plans and elevations of the hot-house erected at Chatsworth, for the cultivation of the Victoria Lily, together with descriptions and explanations by Mr. Paxton himself. This structure is of great interest; showing, as it does, in how simple a manner large spaces may

be covered with glass, and yet be suited for all the purposes of cultivation. It will also indicate the earliest conception of the palace of glass which is to receive the products of industry of all nations in 1851.

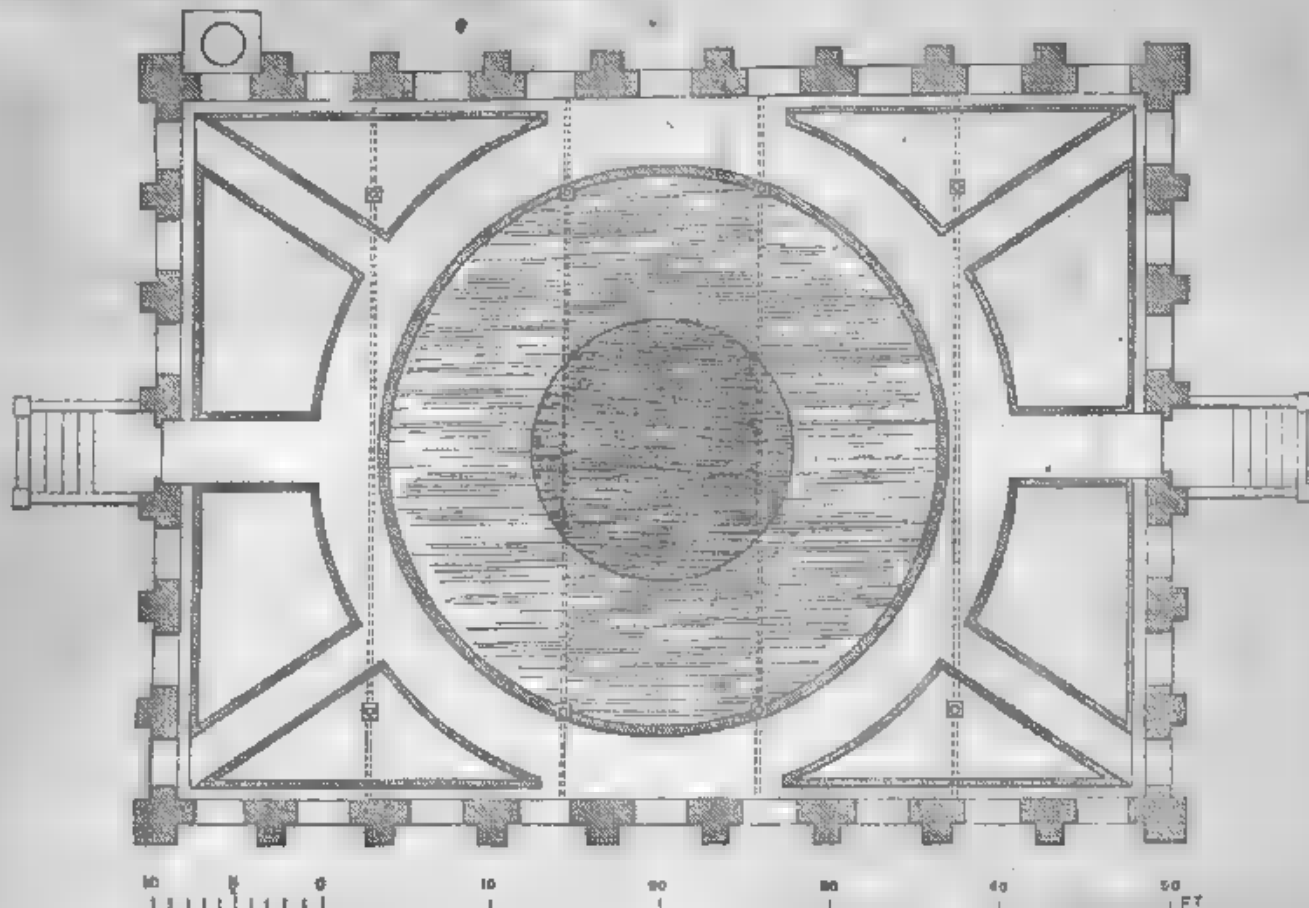


Fig. 1.—Ground Plan.

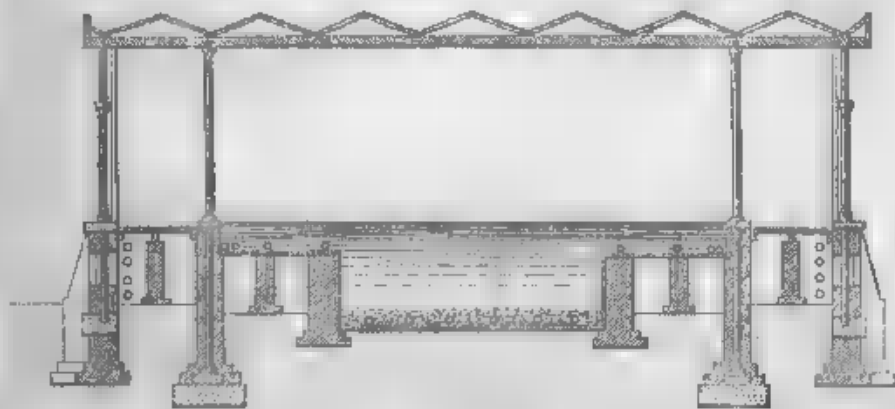


Fig. 2.—Transverse Section.

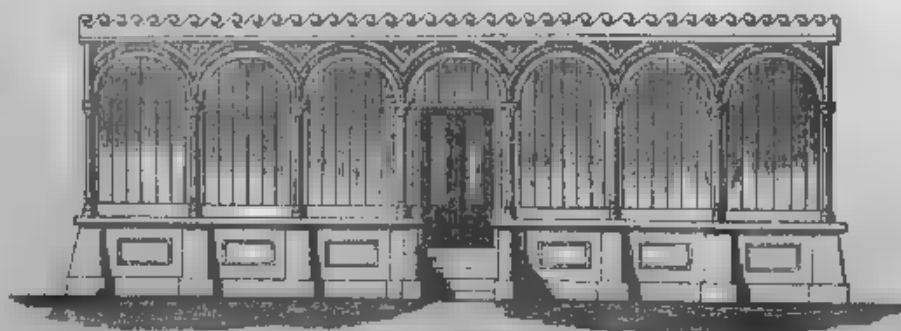


Fig. 3.—End Elevation.

Fig. 1 represents the ground plan, which is 61 ft. 6 in. long, and 46 ft. 9 in. wide over walls. The circular tank is 33 feet diameter, and the centre part, which contains the soil for the plant, is 16 feet diameter. The eight tanks in the four angles are filled with aquatic plants of various kinds. The house is heated by a series of 4-inch cast-iron pipes all round the inside of the external walls, proceeding from a Burbage and Healey's boiler, and Sylvester furnace. The tanks are heated by 4-inch pipes underneath each, as shown in the section; and by smaller sized lead pipes resting on the paved ledge of circular tank, also shown in the section. There are 30 openings between the piers, all round the house, for ventilators. Different compartments of the roof are also made to open by simple machinery, for the purpose of ventilation. The pathways are raised 3 ft. 6 in. above the general level outside, and the roof is supported by light wrought-iron beams, resting on the eight internal columns, as shown on the ground plan.

Fig. 2 is a transverse section of the building, which shows a section of the circular tank, with the pipes under the centre part, and the small pipes on the paved ledge, forming the shallow part of the tank. Also the side pipes, and the manner of fixing the cast-iron columns; together with the construction of the roof and its gutters, fascia board, &c. The wrought-iron beam shown in this section has a bearing in the middle, over the great tank, of 31 ft. 3 in. The height of the masonry, from the ground to the top of the coping, is 4 ft. 6 in.; the column and arch 10 ft. 6 in.; the plating and fascia board 2 ft. 1 in., making the whole height from the ground line 27 ft. 4 in. By this section it will be seen that the upright sashes are placed behind the cast-iron columns.

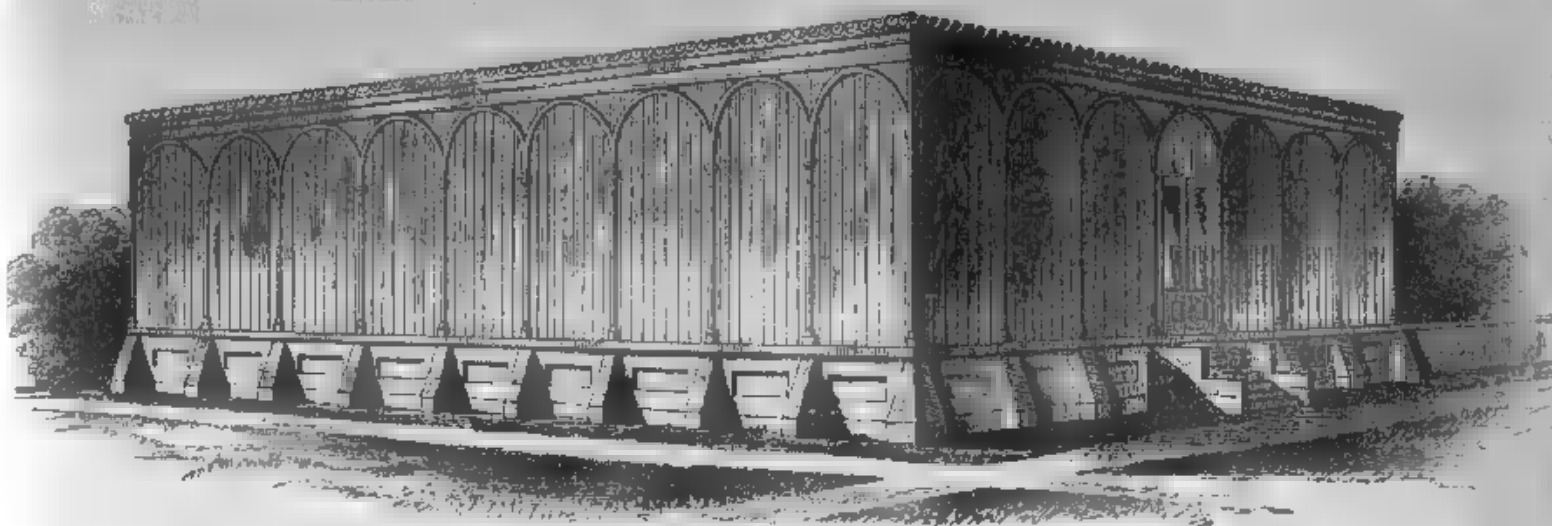


Fig. 4. - Perspective View of the Exterior.

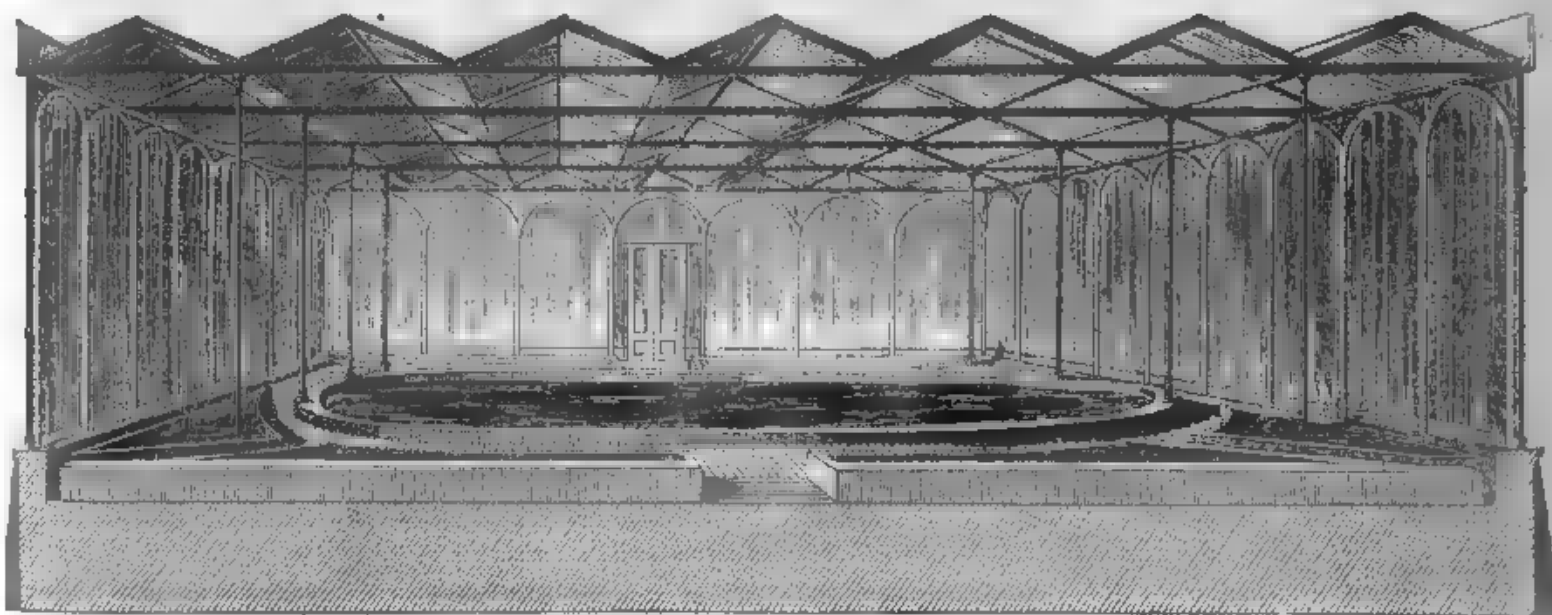


Fig. 5. - Interior View.

Fig. 3 represents the end elevation, and shows the steps ascending to the entrance, the ventilators, cast-iron arches, and fascia board over the plating. The upright glass is 10 inches wide between the bars, and each spandril between the arches is filled in with one piece of plate glass. The columns are 6 ft. 6 in. from centre to centre, and the side elevation of the building presents a series of nine arches, as shown in the exterior view.

Fig. 4 is an angular view of the building; both ends are alike, and both sides are of the same form. On the east side, which fronts the park, the masonry is partly hid by artificial rock work, and the ends and steps to the entrances are adorned with ornamental plants.

Fig. 5 is a parallel perspective representation of the interior, showing the internal construction, the mode of supporting the longitudinal ridge and valley, wooden rafters of the roof, &c.

Construction: Mason, and Castings.—The foundations of external walls and tank walls are built of solid rubble work, well bedded in mortar. The curb of circular tank above the pathways, and curbs of the angular tanks, are of brick, cemented. The tanks are laid with pavement and covered with lead. The external walls are built of picked scabbled coursed wall stone, with piers battering 9 inches, and a plinth formed of two courses of wallstone projecting two inches. The steps to entrances and curb walls of bounding them are of rubbed grit stone, and the walls are covered with neatly boarded and weathered coping. The cast-iron columns are 4 inches at the lower diameter of the shaft, and 3½ inches in the upper diameter. The cast-iron of the arches is 3½ inches wide, by 2½ inches thick, chamfered. The wrought-iron beams are 6 inches by 1 inch, with tension rods 1 inch in diameter.

Carpenter, &c.—The platings are 5 inches by 12 inches, the valley rafters of roof, 6 inches by 4 inches; and the ridge rafters, 5 inches by 5½ inches; with strengthening pieces over each iron beam, and ash bays 1½ inches deep.

The ventilators are bend and flush, hung on the pivot and socket principle, in rebated wooden frames. The stiles and arches of upright sashes are 2 inches thick, together with the doors, which are framed and panelled, and furnished with brass locks and brass butts. The pathways are laid with 1½ inch larch boards, ½ of an inch apart, radiating round the centre tank, and resting upon oak sleepers 4 inches by 3 inches. The roof ventilators are framed and glazed, and hinged to the rafters. The fascia boards are wrought and cut out, as shown on the upper part, with mouldings planted on the plating, to form a cornice. The scroll is completed by painting in different shades. The curbs of all the tanks are finished with a neat rounded edge wooden capping, and the circular tank is provided with a neat railing and hand rail all round. The whole of the house is glazed with sheet glass 4 feet long by 10 inches wide, without overlaps in upright sashes, all being close jointed. Every part of the masonry or brick work seen from the inside, is covered with cement, and the whole of the structure, both externally and internally, is thoroughly painted in suitable and ornamental colours. The accompanying design, described in the foregoing paragraphs, is the type of my design for the building for the Great Industrial Exhibition of 1851. When the large conservatory at Chatsworth was built, a great point was gained by being able to have the glass manufactured in sheets of 4 feet in length; but since that period the improvements in different branches of manufactures have enabled me to make the present Lily-house (though comparatively small) of a much more light and elegant appearance.

It occurred to me that it only required a number of such structures as the Lily-house repeated in length, width, and height, to form, with some modifications, a suitable building for the exhibition of 1851. Hence arose the design for that structure, and the subsequent honour conferred upon me by its successful adoption by her Majesty's commissioners. *J. Paxton. Chatsworth, August 13.*

BRITANNIA AND CONWAY TUBULAR BRIDGES.

The Britannia and Conway Tubular Bridges; with General Inquiries on Beams, and on the Properties of Materials used in Construction. By EDWIN CLARK, Resident Engineer. Published with the sanction and under the supervision of ROBERT STEPHENSON. London: Day and Son. 1850.

In the notice we first gave of this excellent work, we confined ourselves to remarks on the book itself, and the influence which tubular bridges will exercise on engineering, and from the length to which those remarks extended, we were precluded from giving any extract from the book, and which we promised to do, knowing the interest our readers feel in this one of the most important works of the age, and one which will not be least sought after by visitors to this island in the coming year.

In consequence of the requirements of the Admiralty, it became necessary to design a new bridge over the Menai. The first plan for this is thus described by Mr. Robert Stephenson himself:—

"Previous to the erection of the suspension-bridge by Telford, in 1826, various modes and points of crossing had been proposed by Rennie and Telford. Their reports, plans, and opinions, were carefully studied, which led to the adoption of the site known by the name of the Britannia Rock, about a mile to the south of Telford's suspension-bridge. This spot is peculiarly eligible for the purpose, the rock being nearly in the centre of the channel, rising just to high-water mark, and of sufficient area to admit of the easy erection of a pier upon it. The channel is here also entirely free from sunken rocks, and the current unbroken during the ebb and flow of the tide. These peculiarly favourable circumstances were considered highly advantageous, not only for facilitating the erection of a bridge, but for rendering such a structure unobjectionable to the navigation of the Straits. It was proposed to construct the bridge of two cast-iron arches, each 350 feet span, with a versed sine of 50 feet, the roadway being 105 feet above the level of high-water at spring-tides.

"The span here proposed was the same as that which had from the first been designed for crossing the Conway River.

"Such was the state of the engineering problem in reference to the Conway and Britannia Bridges when the company obtained the first Act of Parliament in July, 1844. It was proposed to construct a bridge consisting of one arch of the unusual span of 850 feet over the Conway River, at 20 feet above high-water mark, and another over the Menai Straits at the Britannia Rock, consisting of two arches, each of similar span, but at the elevation of 105 feet above high-water spring-tides.

"The rise of tide in both cases is nearly the same, the channels are also very similar, being from 50 to 60 feet deep, with a rocky bottom, and a rush of tide reaching five miles an hour at Conway, and seven miles an hour in the Straits.

"These conditions, together with the necessity of keeping the channels open at all times for the purposes of navigation, rendered it perfectly clear that none of the methods heretofore adopted in the erection of cast-iron arches could be brought to bear in either of these localities. The inordinate cost of centering, even if other arrangements had admitted of its application, was at once fatal to its adoption; and it soon became evident that some means external to the arch should be employed to suspend the voussoirs, or ribs, until the arch was keyed in.

"A contrivance of this kind had at one time been considered by Telford for the suspension of centering, upon which he proposed to frame and connect the voussoirs, or ribs, of a cast-iron arch; and a slight drawing of such a project is given in the account of the Menai Bridge. Without going into the merits of this proposal in the form suggested, or into its applicability to the present case, it is sufficient to say that it was discarded, and a modification, as brought forward some years ago by Sir Isambard Brunel, for constructing brick arches without centering, taken up as more suitable. Sir Isambard's idea, which was experimentally carried out to a great extent, appeared unexceptionable, and led to the following design for the erection of the cast-iron arches at the Britannia Rock. Instead of the two arches being erected upon two abutments and one pier, it was proposed to treat the abutments as piers also.

"The erection of the arch was to be proceeded with by placing equal and corresponding voussoirs on opposite sides of the pier at the same time, tying them together by horizontal tie-bolts.

"This system, it is confidently believed, may be successfully carried out to a far greater extent than would have been required in the case of the Britannia Bridge.

"It will appear evident, on a little reflection, that as every suc-

ceeding step of voussoirs is secured by the tie-bolts, the tension of the last bolt, as well as all the previous ones, will be relieved by an amount equal to the whole of the horizontal thrust due from the voussoirs last placed.

"If the voussoirs could be constructed or weighted, so that an arch of equilibrium could be formed, all the horizontal tie-bolts might be removed, except the last one, for in such an arch the horizontal thrust is every where equal. It is not meant that such a method of proceeding as that of removing all the bolts could be carried out practically—it is merely alluded to here to show how largely the bolts would have been relieved from strain as the arch progressed into a form which might appear to endanger the stability of the structure.

"Had this plan been carried out, it was not intended to have keyed the arches at the crown, but to have left ample space between the culminating voussoirs to admit of expansion and contraction taking place freely. The bridge would, therefore, have been simply a double-jibbed crane, perfectly balanced on each pier. A connection at the apex of each arch would be necessary, but so contrived as not to interfere in the least with the expansion and contraction, and yet to counteract any tendency to tilt, consequent upon the variable pressure of the passing loads.

"This mode of construction, although decided upon for the Britannia Bridge, was found unsuited for that of Conway. There only one span was required, and the springing of the arch would have been below the high-water line, and from a natural mass of rock on both sides, which, at the east extremity, rose nearly to the permanent level of the railway.

"It was, consequently, impossible conveniently to treat the abutments in the light of piers, as has been just described. Moreover, the great additional expense of this method, where one arch only is required, formed a serious objection to it, as it necessarily involved the use of double the weight of material requisite for one simple arch, the weight of each overhanging wing being equal to half the weight of the arch itself.

"The objection on the score of expense did not apply to the Britannia, for there the overhanging wings were a useful portion of the bridge, and formed a substitute for the extension of masonry, which would have been nearly as costly. Both the expense, therefore, and the peculiarity of the site of the Conway Bridge, pointed out the necessity of some other method being devised for the erection of the arch. Various modes for erecting and supporting a fixed centering were considered, but none appeared satisfactory or safe; whilst the formidable difficulty of stopping the navigation, and seriously interfering with many vested interests for probably two years, remained in all its force.

"This state of things led to the idea of building the arch complete on centering supported entirely upon, and framed into, a series of pontoons kept afloat during the whole time of construction.

"The rise and fall of the tide was such as to admit of its being brought immediately above the springings and lowered into its place by the falling tide, or by admitting water into the pontoons at the top of the tide, before the velocity of the ebb stream had increased so as to interfere with the accurate adjustment of the descending mass. This method of fixing arches I have since learned was proposed many years ago by Mr. Dixon, of Darlington. He made designs for a cast-iron bridge across the River Tees at Stockton, and, instead of erecting centres on the permanent site of the arch, he proposed to use pontoons, precisely in the manner which has been described. These plans were not carried out, in consequence of the Stockton and Darlington Railway Company having determined to try a suspension bridge for railway purposes instead of the cast-iron arch. For a brief description of the particulars of the novel proposal of Mr. Dixon I have been favoured with a communication from Mr. R. B. Dockray, who resided at Darlington at the time when Mr. Dixon made the design. I have also learned from Sir John Rennie that this was the method adopted for placing the centering of the Waterloo and London Bridges; the centres being constructed on pontoons and floated and lowered into their proper position."

We very much regret that this ingenious plan of Mr. Stephenson was not adopted, in consequence of the hostility he had to encounter on the part of the government; but we hope the opportunity will present itself for its realisation under his direction.

In reference to one of the original forms of the tube, the circular, Mr. Edwin Clark makes some interesting remarks.

"It is to be regretted that circular tubes, with thicker plates, were not experimented upon; as subsequent experience has shown

that no distortion would then have occurred, and valuable results would probably have been obtained. Permanence of form might, moreover, be entirely ensured by diaphragms or stops, at intervals, throughout the tube, or by stiffening-plates united by angle-iron, as in the bridges. Such diaphragms have, indeed, been successfully adopted by Professor Airy in using wrought-iron tubes for the support of astronomical instruments, to which purpose they are peculiarly applicable, on account not only of their stiffness, but of their greater freedom from vibration or tremor than cast-iron supports. Diaphragms are used in the construction of the wrought-iron polar axes of the large equatorial telescope in the Observatory of Liverpool, which are formed of two semi-elliptical boiler-plate tubes, of exquisite workmanship.

"Circular wrought-iron tubes, of considerable thickness, and of magnificent dimensions, retained in shape by stops, are also being used by Mr. Brunel in the construction of a bridge over the Wye, at Chepstow in South Wales. These tubes are, however, not strained transversely, except in supporting their own weight during the process of erection, and for this purpose it is intended to render them temporarily more rigid by cambering them to a slight extent by tie-rods along the bottom. They are 305 feet long, 9 feet diameter, and $\frac{1}{2}$ inch thick; and are employed as struts, or pillars, to resist the horizontal strain of the suspension links which support the wrought-iron girders of which the bridge is composed. By these means, without the usual tie-chains of a suspension-bridge, the lofty towers are relieved from all lateral strain.

"The total span of this bridge is 300 feet, which is the length of the circular tube employed as a strut; a chain, consisting of three straight links, suspended from this strut, divides the span into three equal portions of 100 feet each. The beam carrying the roadway is thus a continuous beam, 300 feet long, supported at each end and at two points in its length. The circular tubes are supported on cast-iron standards.

"Circular tubes, 100 feet high, were also at one time proposed as supports for the platforms in constructing the abutment-tubes of the Britannia Bridge.

"The round tube, as proposed for the bridge itself, if suspended in chains, and merely applied as a means of ensuring a rigid platform, would, if constructed with thick plates, properly united, have formed a most efficient structure, offering but little resistance to the wind, and having equal rigidity in every direction; while an elliptical tube of the depth necessary for the Britannia Bridge, and well retained in shape, possesses several important advantages as an independent beam. The curved plates of the top are well adapted for resisting compression, and for throwing off the wet, while the heavy riveting necessary for uniting the sides with the top and bottom in a rectangular tube is entirely obviated; although there are other more important practical advantages in favour of the rectangular form.

"We have many instances, in the vegetable kingdom, of the extreme rigidity and strength of circular tubes; the stems of the grass tribe generally are remarkable for their lightness and strength; the common wheat-straw and the river reed are familiar examples in our own climate; but in the tropics the gigantic stems of the bamboo and other grasses tower sixty feet above the jungle, and are extensively employed as beams for covering buildings, and even, in some cases, as the transverse bearers of light suspension bridges. The angler's bamboo rod is the most perfect of tubular beams. Tapered off in proportion to the strain, its silicious coat (as in all the grasses) defies compression, while it is internally lined with woody fibre to resist extension in every direction; its strength, lightness, and stiffness, are thus equally marvellous; and we cannot fail to be struck with the provision of diaphragms throughout the whole tribe, to preserve the circular form, which addition would certainly have much modified the results obtained from thin circular and elliptical tubes of wrought-iron.

This illustration from the vegetable kingdom, is only one among many examples of the writer's happy power of treatment, and will enforce upon our readers the importance of the study of animal mechanics, which so far as we are aware is not taught in any engineering college.

In reference to the ultimate length to which it is possible to carry the tubular bridge, Mr. Edwin Clark has several remarks, which we think will prove of interest to our readers, and in the discussion of which Mr. Clark again alludes to the works of nature.

"Again, if we make a tube similar to another, increasing every dimension except thickness, the absolute strength will be directly as the increase, that is to say, another tube twice the length, depth, and breadth of the Conway Bridge, but of the same thickness, would

be just twice as strong; it would, however, be four times as heavy, and hence have four times the strain from its own weight, and would, therefore, soon come to a limit at which it would break itself.

"This is evident by considering that with tubes of similar section, in which the thickness is not altered, the sectional area will be simply as the increase, and not as the square of the increase; the strength will therefore be simply as the linear dimensions, instead of as their square.

"But if we increase a tube in depth, and length, and width, and preserve its sectional area constant, that is, if the plates are thinner in the same proportion as the tube is enlarged, then the absolute strength of the enlarged tube *ad infinitum* will be the same as that of the first. So that by keeping the same sectional area as at Conway, and enlarging in the same proportions the length, breadth, and depth, we may make a tube of any length, equally strong, theoretically, with the Conway Tube. For the strength is directly as the sectional area into the depth, and inversely as the length, and the sectional area being constant, as

well as the ratio $\frac{\text{depth}}{\text{length}}$ the strength will also be constant; but the weight of the tube, and hence the strain from its own weight, would increase as the length; and, consequently, if we suppose the strain to be five tons per square inch at present in the Conway Tube, another tube of the same sectional area, and of three-and-a-half times the same length, breadth, and depth, would fail by its own weight. Such a tube would be 1400 feet long, and no increase of thickness would make such a tube bear more than its weight.

"We have already alluded to the strength of the bamboo as an instructive natural example of the strength of a circular tube. The bones of animals are oval, the depth being always in the direction of the transverse strain. But the more special province of the bones appears to be their action as pillars, or struts, in forming immovable fulcra for the reaction of the muscles; and since any yielding would involve a great increase of motion in the muscle itself, we find bone among the most incompressible of known substances.

"The square form of stem characterises a very extensive natural family of plants—the labiate tribe, of which the beautiful dead nettle of the hedgerows is an example; though it is difficult to assign any mechanical reason for this peculiarity, which appears rather to be typical of the general development of these plants. But in the feather-bearing part of the ordinary quill we have a most remarkable example of the strength of the rectangular form. Here, again, every dimension is tapered down in proportion to the strain, with an accuracy defying all analysis; the extended and compressed portions are composed of a horny substance of prodigious strength, though extremely light and elastic. The beam is not hollow, but to preserve its form it is filled with a pithy substance which replaces the clumsy gusset pieces and angle-irons of the tube without interfering with its pliability; the square shaft is peculiarly available for the attachment of the deep vanes which form the feather; and as the angular form would lacerate its active bearer, an exquisite transition to the circular quill at the base is another striking emblem of perfection. The imitation of such mechanics, so wonderfully adapted to such a medium, appears hopeless; but we are indebted to the flying philosopher, if his attempt only calls attention to such design, and induces us instructively to contemplate the beauty of a feather."

REMARKS ON SPIRIT-LEVEL ADJUSTMENTS.

There are some misapprehensions prevalent affecting the manipulation required for properly adjusting the spirit-level, and the reasons which occasion it. Such errors, if copied from one text book into another, are likely to mislead some of the profession, who may not have leisure to examine for themselves.

The object of the adjustments should be to enable us to obtain at any place a straight line of sight, revolving in a plane; this plane to be a tangent to the earth's surface at that place.

The term *optical axis* is sufficiently explanatory; the term *line of collimation* is not so. Mr. Simms, in his 'Treatise on Levelling,' writes, *optical axis, or line of collimation*. This description, if intended for the old-fashioned Y-level, in which both should coincide, would be correct; but is inapplicable to that with fixed telescope at present in general use. In the latter the adjusted line of sight may or may not form an angle with the optical axis of the lenses. Provided the line of sight be parallel to the bubble, and

at right angles to the vertical axis on which the telescope turns, it is of little consequence whether or not the line of sight be precisely in *directum* with the centre line of the lenses. The amount of distinctness occasionally lost by the want of this coincidence is altogether inappreciable.

If this then were the only difficulty attending the adjustment of the diaphragm, we could not do better than, pointing the instrument at a placard lettered with various type at some distance, move the diaphragm up or down, until the horizontal wire appearing in centre of the field might be seen to intersect those letters most distinctly defined. The adjustment required is, however, of a different nature. Mechanical error would almost unavoidably, during focal adjustment, cause the focus of the eye-piece to deviate from the path of a line of sight so determined upon, since it is very doubtful whether it would be possible to construct tubes to slide one within the other with the nicety which this would require. This source of error, with a remedy, was first pointed out by Mr. Gravatt; but his method seems (as I shall show) to be at least liable to misinterpretation, if not capable of improvement, and perhaps correction. The object of his adjustment he defines to be, "to examine and correct the line of collimation." Had he, instead of this, described it as a process to correct error arising from focal adjustment, mistake on this head would not have been so likely to occur. Having described the process, to which I shall have occasion again to revert, he adds: "The instrument will now be in complete practical adjustment for level, curvature, and horizontal refraction, for any distance not exceeding 10 chains, the maximum error not being more than $\frac{1}{16}$ th part of a foot." This might perhaps have been with advantage omitted, as the three sources of error alluded to in this paragraph, remain unaltered by the adjustment described—the same exactly whether the adjustment had taken place or not.

1°. The steps of this adjustment involve the following principle: three stakes, A B C, are driven in to the ground, equidistant, and tops in a curve of true level. Set the instrument up at A, using the bubble merely to see that you do not disturb the instrument; take the readings of the staff held on each stake consecutively, and if the difference of the readings at A and C be four times the difference of the readings at A and B, the line of sight is unaltered by focal adjustment, on the principle that the radiating differences between true and apparent level vary as the squares of their respective distances from the point of contact of the tangent and curve; if not, alter the diaphragm till this proportion take place.

2°. Next, lower or elevate the telescope by means of the parallel plate-screws until the line of sight so adjusted and apparent level coincide, and set the bubble parallel to it.

3°. Get the line of sight and bubble at right angles to the vertical axis of the telescope in the usual manner.

With regard to No. 1, which from its importance deserves most consideration, since the bubble is used merely to see that you do not disturb the instrument, the line of sight may be a *secant* to the curve marked on the ground, and not a tangent, which circumstance might negative this adjustment without due precaution; but if the bubble and optical axis are nearly parallel when the instrument is obtained from the optician, and the bubble be brought to the centre of its run previous to taking the readings, I do not believe sensible error likely to accrue from this source.

The manner in which focal error is got rid of may be explained as follows: Suppose the instrument placed, the set in apparent level, and a staff held vertically at a considerable distance, appearing in the centre of the field of the telescope. Suppose, further, this staff to advance or recede, without altering its relative position to the optical axis; a single point of the image of the staff will travel backwards or forwards horizontally within the tube; the paths of the remaining points will all be less or more inclined to the optical axis, forming every variety of angle with it, according as they are nearer to or further from this normal point. Suppose, further (which is more than probable), the tube carrying the eye-piece not to slide in *directum* with the optical axis, but in another line, we must then raise or depress the diaphragm out of the optical axis, till the cross hair meet a ray from the staff whose path shall coincide with that of the focus of the eye-piece during focal adjustment. This is evidently possible, and no method better to effect this than Mr. Gravatt's, with the precaution already mentioned.

This adjustment, once made, need never be repeated. The remaining two adjustments may then be performed in the usual easy manner.

There is, however, considerable grounds for supposing misapprehension to exist on this head among many who practice and some who write. I shall conclude these remarks with a specimen of the latter kind, taken at random from a text-book lately published, where, speaking of Mr. Gravatt's method, the writer says: "We are indebted to Mr. Gravatt, of whose level we shall hereafter speak, for a method of collimating which satisfies the above requirements, and removes any error arising from imperfection in the slide of the telescope, while at the same time the line of collimation is set with the end at the object glass slightly depressed, instead of exactly horizontal, so as to remove, or nearly so, the errors arising from the curvature of the earth, and the horizontal refraction."

Cirencester.

J. D. PEMBERTON.

BRITISH ASSOCIATION.

Selections from Papers read at the Meeting held at Edinburgh, August, 1850.

(Continued from page 304.)

Description of a New Arrangement of Reflecting Telescope, by which much comfort and convenience is secured to the Observer. By JAMES NASMYTH.

In introducing this subject to the attention of the members of the Mechanical Section, Mr. Nasmyth, with a view to render the description of his improved arrangement of telescope more clear to such members as might not be practically conversant with the subject in question, premised his description by a sketch of the various forms of reflecting telescope which had hitherto most generally been in use. These are seen in fig. 1, 2, 3; fig. 1 being



FIG. 1.—NEWTONIAN.



FIG. 2.—GREGORIAN.



FIG. 3.—CASSEGRAIN.

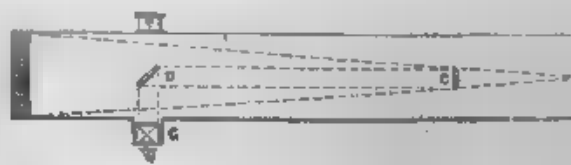


FIG. 4.—NASMYTH.

the Newtonian, which is the arrangement most generally in use for the larger and most powerful instruments. It will be seen, that in the case of fig. 1, the object is viewed by the observer placing his eye at the side of the tube, and at the end most distant from the speculum S, the image of the object being seen in that direction by means of the employment of the small diagonal plane mirror at D. In telescopes of this construction, the eye of the observer is placed near the upper end of the telescope; thus, fig. 6. It is therefore requisite that he must change his situation almost constantly, so as to follow with the telescope the movement of the star, or other astronomical object he is desirous to look at. In telescopes of a moderate size, this may not be found to be a very serious source of inconvenience; but when we come to employ instruments of this class, of a larger and more powerful description, the difficulty of following the eye-piece of the instrument, when its posi-

tion has to be changed, so as either to follow the object or pass

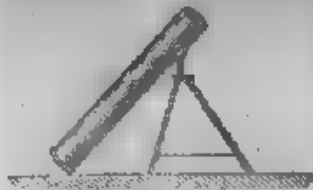


Fig. 4.

to another, is felt to be very great; and even although many excellent arrangements of mounting have been proposed to overcome this difficulty, yet so much personal inconvenience, discomfort, and trouble yet exists in all of them that the attention of the observer is in no small degree occupied and divided between regard to his own

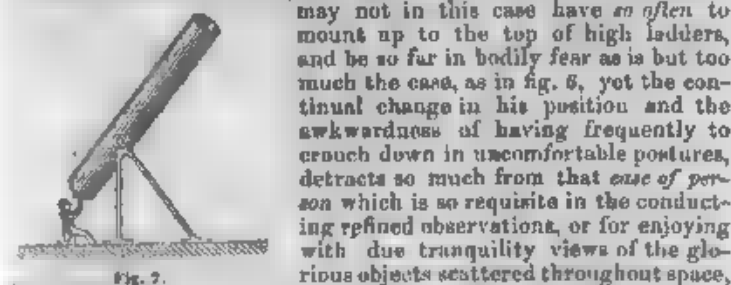


Fig. 5.

comfort and safety, and the actual object in view. Although such discomforts might in some respect be reduced in the case of the employment of the arrangement, fig. 4, namely, that of the Gregorian; or fig. 3, that of the Cassegrain construction, in both of which it will be seen that the observer views the object from the lower end of the tube, thus, fig. 7; yet although the observer may not in this case have so often to mount up to the top of high ladders, and be so far in bodily fear as is but too much the case, as in fig. 6, yet the continual change in his position and the awkwardness of having frequently to crouch down in uncomfortable postures, detracts so much from that ease of person which is so requisite in the conducting refined observations, or for enjoying with due tranquillity views of the glorious objects scattered throughout space,

that after considerable experience with telescopes of a large class, Mr. Nasmyth bethought himself of such an arrangement as would remove most of these objections. The optical department of this arrangement is seen in section in fig. 4, where it will be observed that, by the union of the Newtonian and Cassegrain construction, in so far as respects the turning back of the cone of rays by the small convex mirror, C, and receiving them at D, by a small diagonal plane mirror, D, the rays which ultimately form the image of the object are sent out sideways through the trunnion, G, in which the eye-piece is placed, and through which, in fact, the observer views the object.

By having a corresponding trunnion at the opposite side, T, and employing these trunnions as the supports of the telescope, and using them as the axis on which it is moved in altitude, it will be evident that, as the eye-piece, G, is thus in the centre of motion, whatever be the sweep of elevation in moving the telescope vertically from object to object, no change in the position of the eye of the observer will be required; his eye, while opposite to the trunnion, is common to all positions of the instrument in altitude; his eye is virtually in the centre of motion.

But as the telescope has to be moved round so as to follow the motion of an object in azimuth, it is desirable that the observer should not have to change his position even in this respect. Therefore, in order that he may sit at his ease opposite to the eye-piece while the telescope is moved either in altitude or in azimuth, all that has to be done to attain this object is to place the entire instrument on a turn-table, and have a comfortable seat for the observer also on the turn-table, and then, whatever be the elevation or direction in which the telescope is pointed, the observer need never stir from his comfortable seat; and as we all now know with what ease ponderous machines, such as railway wagons or locomotive engines, can be swung round on properly constructed turn-tables, and also the ease with which a well-balanced mass can be swung when it centres, some idea may be formed of the perfect ease and facility with which such an instrument as this of Mr. Nasmyth's can be governed and directed by the observer, who has, by means of suitable handles brought close to his chair, the most perfect command of every requisite movement. The instrument in question, which is represented in fig. 5, weighs upwards of two tons, can be moved in every direction by the point of the finger, swung round in an instant, or elevated to any object on a slow motion given to it so as to enable the observer to keep the object in the centre of the field for hours. Such is the perfect steadiness of the motion, that not the slightest tremor is perceptible, even when observing with a magnifying power of 450 times. Some objection may be urged against the optical arrangement by which Mr. Nasmyth has brought his telescope to yield this central vision, in so far that it is requisite to employ a third reflecting surface, namely, the small plane diagonal mirror (D, fig. 4,) by means of which we are enabled to view the object through the hollow trunnion G', fig. 4, or H, fig. 5; no doubt some portion of light is

sacrificed by the employment of this third reflector; but when we obtain in exchange so vast an amount of convenience and comfort as result from the adoption of this arrangement of Mr. Nasmyth, most observers will be happy to accept the exchange, and with the advantage of the ease, comfort, and tranquillity resulting from the absence of all personal sources of interruption, Mr. Nasmyth presumes that by thus inducing more frequent and careful observations, science will be advanced.

Mr. Nasmyth stated, that the main object he had in view in constructing this large telescope was not so much to pursue observations of objects of the fainter class, as nebulae, &c., but rather for following up a series of observations in reference to the structure of the lunar surface, on which subject he has been occupied for several years; and such has been the increased comfort and facility which this truly manageable and powerful instrument has given him, that, judging from the specimens of the "drawings from nature," of the remarkable features of the lunar surface, which he exhibited to the section, the optical powers of his instrument are equal to its convenience and comfort to the observer.

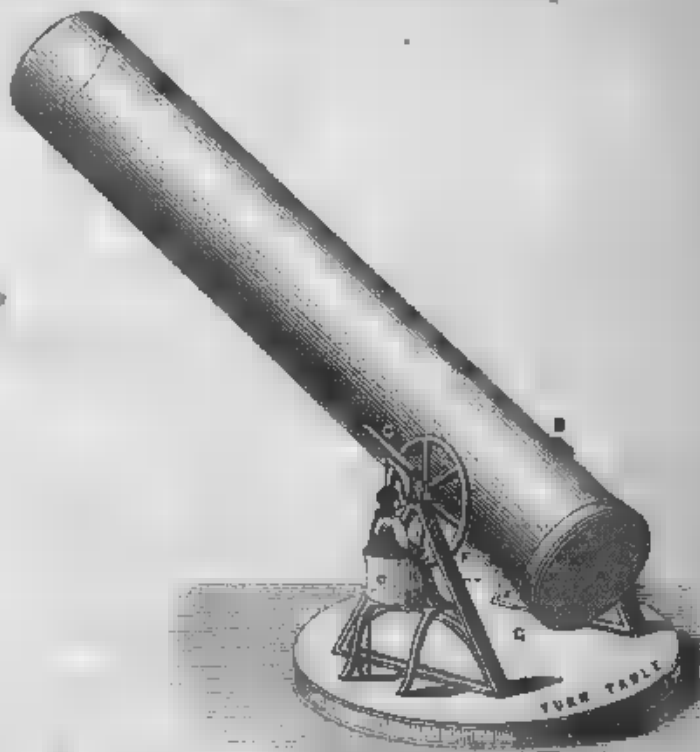


Fig. 5.

Fig. 5 is a perspective view of Mr. Nasmyth's "Comfortable Telescope;" C is a cast-iron turn-table, which, on being moved round, carries with it the entire instrument, and the observer, who, seated in a comfortable chair, has complete control of the elevation and round-about motion; the former by means of a tangent screw and wheel, F, the latter by tangent screw and pinion-shaft, E, which commands the roundabout or azimuth motion. An eye-piece is placed convenient to the eye of the observer at G. Some idea may be formed of the facility with which the movements can be controlled, when it is stated that within two minutes Mr. Nasmyth has frequently directed this large instrument to nine different objects situated in various parts of the heavens.

Mr. Nasmyth, at the request of the president of the Section, gave some description of his mode of securing perfectly sound castings of specula for such large instruments, of which we hope to furnish our readers some account in our next number.

On a Patent Steam Plough. By JAMES UMAN.

Mr. Uman described his Patent Steam Plough, and stated that many fruitless attempts had been made to cultivate the land by steam-power, the reason of which had been that the parties had proceeded on an entirely erroneous principle; as, from the method they have pursued, they could never get the machine to proceed along the land. This can be simply explained by stating that all former

attempts have gone on the principle, that ploughs must be *dragged* through the earth. Now, if we consider for a moment, it will be seen that the ploughshare and its bearer are exactly similar to a common anchor; which, if thrown into the sea, it will hold the largest vessel fast, much more than a small engine of 10-horse power. To obviate this great difficulty, in the present machine the plough is reversed and made like an anchor, thrown out afore ship, by which the sailor hauls his vessel into position; and thus, instead of making the anchor a power to hold the vessel back, it is here made a power to pull it forward; or, in other words, the plough is inside a paddle-wheel, instead of an anchor cast astern, and thus the carriage is propelled along the land. In thus making the plough a paddle-wheel, the next difficulty was, that five or six ploughs entering the earth at the same time would lift a solid piece of earth, and carry it round; while, to put the ploughs each on a separate axis, would involve such a length of machine that it might not work. To obviate this, all the ploughs are put on the same axis, and each share is placed a little behind the preceding, by which arrangement no two shares come into action at the same moment, and the first set have turned over their given quantity of earth before the next set enter the land.

Fig. 1.

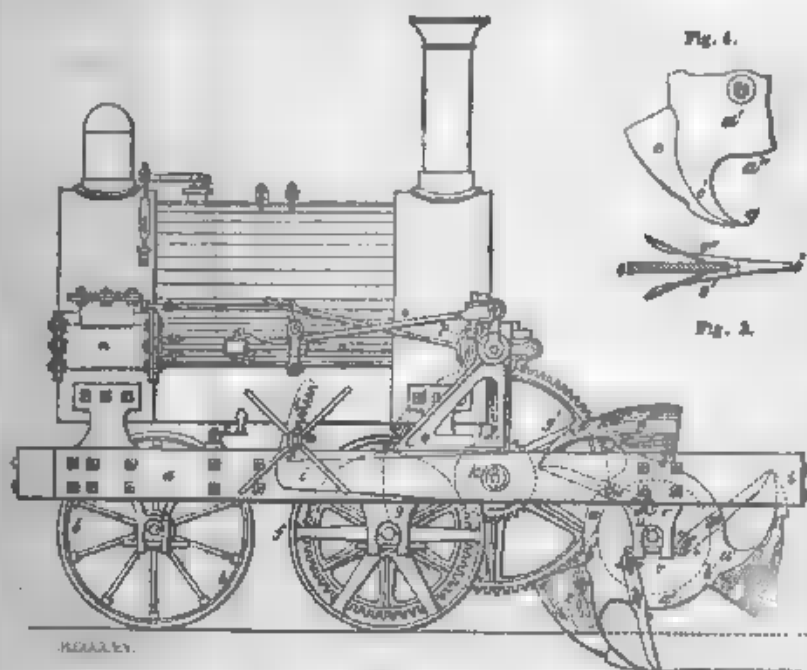
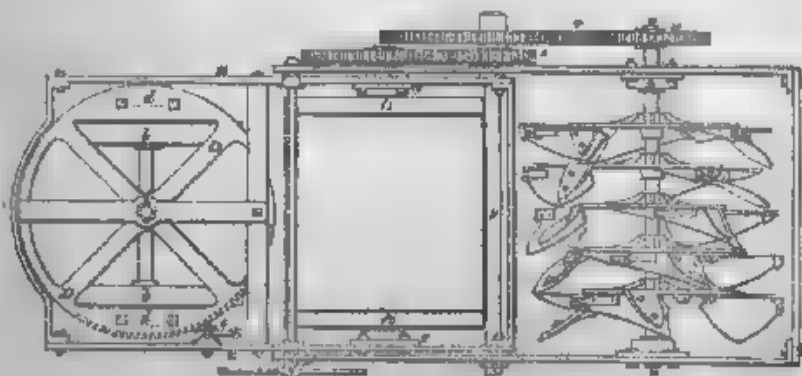


Fig. 2.



On applying the power of the steam-engine to the ploughs, it was found they ran along the earth without turning it over, and it became necessary to put a drag on the wheels, to prevent the carriage running away from its work; but instead of putting on the common railway drag, it was thought better to connect the wheels of the carriage with the wheel which drives the ploughs. Thus is obtained a uniform stroke for each plough as it enters the earth, and it cannot proceed until it has turned over the desired area. By this it will be perceived the ploughs drive the

carriage-wheels at the necessary reduced speed, the forward motion of the machine being communicated from the plough to the carriage, instead of from the carriage-wheels to the ploughs, as in many agricultural implements now in use; or, to apply again a former simile, the paddles drive the vessel, instead of the vessel driving the paddles. Mr. Usher then proceeded to show a working model of the plough.

Fig. 1 is a side elevation. Fig. 2 is a plan of the underside. Fig. 3 is a plan of a plough when two mould boards are used, in cases where it is desired to turn the land on either side; and Fig. 4 is a side view of one of the ploughs on its axis, by which and by Fig. 1 it will be seen that the under edge of the mould board and share is formed to a curve struck from the centre of the shaft or axis on which the ploughs are affixed; a a indicate the bed-frame or carriage of the machine. The fore carriage wheels b b are mounted on an axle, which turns in bearings c attached to the swivel frame D, which moves on the bolts d for the purpose of causing the machine to turn round in a small space. A portion of the swivel frame D is toothed, and acted upon by the pinion and winch e; the hind-part of the carriage is here shown supported upon the hollow cylinder or roller f, composed of two extreme parts, f' and f'', which are wheels similar to b b, the intermediate part f' being by preference removable at pleasure, so as to render these bearing parts suitable to the different stages of cultivation to which the machine may be applied. This compound cylinder has its axle supported in the bearings g attached to the lower, or to the under side of the carriage frame. The axle of this cylinder carries also at one end the wheel h, to be afterwards noticed.

A moveable lever frame i, i, i, i, is supported on an axle or shaft k, as a fulcrum. The free ends f' f' are formed into the toothed segments a, and are concentric to k, these segments being acted upon by the two-toothed pinions and spindles m, which elevates or depresses the hind part f' of the lever frame, and all that it carries, at the pleasure of the conductor.

On the carriage thus constructed is placed the locomotive boiler, with its engines of any ordinary construction, as n n, the power of which is applied through the medium of connecting rods o to the crank shaft p, the two arms of which stand at right angles to each other, in the usual way. The crank shaft p is supported on two standards q securely fixed to the carriage. On the shaft p there is also fixed the spur pinion, indicated by the dotted circle p' p' in fig. 1; and this pinion, by taking into the wheel r, mounted on the shaft k, gives motion at the same time to the piston f, which is carried round on the same shaft k. The pinion f, thus actuated, takes into the wheel h, before referred to, on the bearing cylinder f'; and it is preferred that the pinion f should be applied so as readily to be put into and out of gear with its wheel, though not so shown in the engraving. By this arrangement of parts, a slow progressive motion is obtained for the whole machine, on the one hand through the cylinder f, and on the other hand a separate rotatory motion, at a certain increase of speed, is communicated through the wheel r to the pinion u, fixed upon the piston u u, which last-named shaft has its bearings v v attached to the moveable frame i i.

On the shaft u u are placed a series of plates or projections, fixed at regular distances. Or such plates or projections, with their ploughs afterwards described, may be placed upon separate shafts, each with its own proper gearing; but it is preferred to place them on one shaft. These plates or projections on the axis are shaped in such manner as to receive and have affixed to each of them several ploughs, adapted by their revolving motion to penetrate the soil, and by their mould-boards to elevate and turn over portions thereof; a a are the plates or projections fixed upon the shaft u; they are each formed with a strong boss at the centre, by which it may be securely fixed to the shaft. Each plate a' has three arms or prolongations b, b, b, which terminate in the radial direction shown; a further prolongation d' d' is carried obliquely upon each of these arms. Upon the plate and projections thus constructed is affixed the tilting apparatus, which consists, firstly, of the part e', which acts the part of the mould-board or turn-furrow in the common plough; and it is to be fixed by screw bolts or otherwise to the prolongations d' d'. To the fore part of this mould-board e' is affixed a bar f' of wrought-iron, which is also furnished with a lug f'', by which it is attached to the plate, by means of screw bolts or otherwise; the bar f', thus secured, forms a head or share bearer, as in many common ploughs. To the fore part of the bar f', the share g is adapted, and fixed by its socket. The mould-board, and also the share, may be varied in form. A fore-cutter, or coulter h' is affixed in front of each share, by screw bolts or otherwise, and is provided with the means of adjustment through the counter slit, in itself, and in the plate; but, in order to meet the different qualities of soils and the various stages of tillage, the further provisions shown in figs. 3 and 4 are employed. Fig. 3 shows a variation in the form of the plate a of figs. 1 and 2. u is

the shaft, as before, carrying the plates or projections; a' shows a detached portion of one of these plates, in which the curved part a'' to a'' is brought forward and armed with a steel blade, answering the purpose of the separate coulter N in Fig. 1; e is the mould-board, and f the share, as before. Fig. 2 is a furrow of plough suitable to the tillage of green crops; a' is a portion of the plate or projection, seen edgewise; e' and e'' are right and left mould-boards, and f' a plain spear-shaped share. The number of plates or projections, and also the number of ploughs in each, may be varied.

On a Gas Stove. By Mr. W. B. WARR.

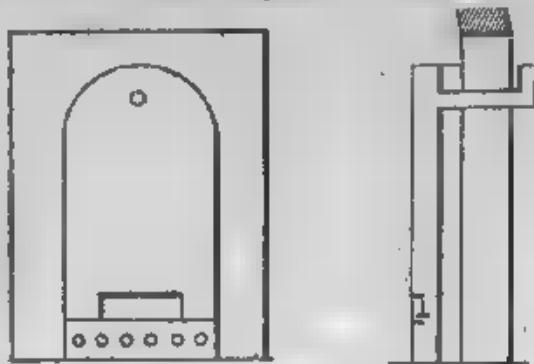


Fig. 1.

Fig. 2.

The novelty of the stove consists in constructing it of iron plates in a vertical position, so as to expose considerable surfaces for the absorption of heat from jets of gas, and for the radiation of the heat. The author found that his apparatus was sufficient to raise the temperature of a moderate sized room from 5° to 10° Fahrenheit, with a consumption of about three feet of gas per hour, costing about 2d. for ten hours; and that it was particularly useful in warming a bed-room, where only a slight elevation of the temperature was required, and free from the production of dirt or smell.

The annexed engraving, fig. 1, is a front view of one of the stoves, and fig. 2 a vertical section; it consists first of a sheet of plate-iron to fill up the usual opening of a fire-place, with a hole through for a chimney, and two other plates of iron placed about three inches apart, and inclosed round the rim; near the bottom are perforations to admit air, and a small door with a burner, consisting of several small jets inside; when the gas is lighted, it heats the air inside, and the surface of the two iron plates; by this arrangement all unpleasant effluvia is conveyed away through an iron pipe that is made near the top, and which leads into the chimney of the room.

Mr. McPherson explained an Apparatus for preventing Water-pipes bursting by Frost. The apparatus is shown in the annexed figure, and is acted upon by the expansion of water, just as it is on the point of freezing. Let A represent the supply pipe; B a double-action valve; C the waste-pipe; F a copper tube containing the liquid to be frozen; D, the bracket to support it to an iron plate. Now, if frost acts on the copper tube F, it will expand the water therein, elevate the piston E, and push up the valve B, from its seat, and thereby open a communication with the waste-pipe C, through which the standing water in the pipe A, escapes, and finally shuts against the supply pipe A, thus accomplishing the shutting off the water and emptying the pipes.



A new Method of Supporting the Speculum of Large Telescopes. By Mr. LASSALL, of Liverpool.

Mr. Lassall explained by a diagram the method he proposed to construct the speculum of large reflecting telescopes to prevent any sensible flexure. This he proposes to do by casting on the back of the speculum several ribs, and placing an additional plate behind with several perforations, each having a pin or lever supported on centres,

when the speculum is placed in a horizontal or inclining position. It is supported by these pins or levers acting against the ledges of the ribs; for a 9-foot speculum he proposes to cast five ribs at the back, and have about eighteen pins or levers to support it.

Mr. BUCHANAN explained a new kind of Valve for Waterworks. It consists of a flexible web made of India rubber strained over a metallic surface, having one or more hollow grooves, or a hollow space. When there is the slightest pressure on the top of the valve, the flexible web completely seals the aperture over which it is placed. The annexed engravings show two examples of Mr. Buchanan's invention fig. 1; A is a valve with a plate having two grooves covered with a web b of india-rubber; c is a dead plate

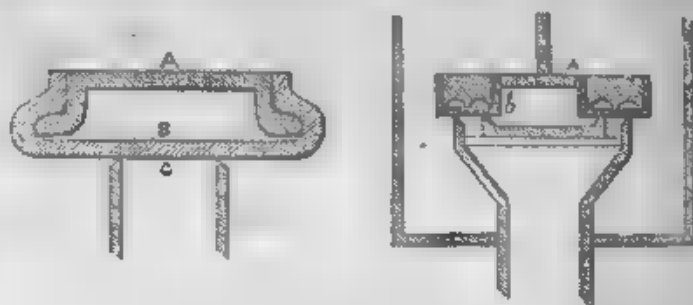


Fig. 1.

Fig. 2.

with a raised rim fixed in the orifice, and d is the orifice of a pipe with a knife-like edge. When the valve A is pressed down, the web where the grooves are, is gently pressed against the two edges of the plate c and orifice d , and closes the aperture. Fig. 2 is another form; the valve A has a hollow plate covered with the web, which, when pressed against the edges surrounding the aperture c, completely closes the opening.

On a new and ready Process for the Quantitative Determination of Iron. By Dr. F. PANNY.

The author recommends the employment of the chromate and bichromate of potash for the estimation of iron in the common ores of the metal, and especially for the analyses of the clay-band and black-band ironstone of this country. He was led to the application of these salts in the course of some investigations on the materials and products of the manufacture of alum from "alum-shale," in which he was much retarded by the want of a ready method for estimating the oxides of iron. The chromates of potash give very exact results, and possess the great advantage that a much larger quantity of material may be operated on than can be conveniently treated by the usual methods. For practical purposes, he says, the bichromate is to be preferred. The process requires no other apparatus than that commonly used for centigrade testing, which is familiar to all persons engaged in chemical pursuits. It may be easily and rapidly executed, occupying only a fraction of the time required for the process of estimating iron by precipitation as the sesquioxide; and it is not interfered with by the presence of alum and phosphate which usually exists in the ore. The method is based on the well-known reciprocal action of chromic acid and protoxide of iron, whereby a transference of oxygen takes place, the protoxide of iron becoming converted into sesquioxide, and the chromic acid into sesquioxide of chromium.

A Notice of very powerful Magnets made by the process of M. Elias and under his direction, by M. Legemon, Optician, Haarlem. By Sir D. BRIDGES.

By this process a magnet 1 lb. weight will, with due precaution, support 2½ lb., and the power does not sensibly diminish though the armature be suddenly detached several times. It has twice the power of magnets commonly made in Britain. Magnets capable of raising 400 lb. are made in this way. Sir David exhibited two of M. Elias's magnetic horseshoe combinations of bars, one of about 17 oz. weight, and another of 12½ lb., the latter capable of supporting 150 lb. It was necessary, for their perfect action, to polish the ends of the armature with two pieces of wood covered with emery and lead. The line joining the poles must be as perfectly horizontal as possible. The bars are magnetised by being moved several times through a helix of copper wire, along which the galvanic current passes.

Dr. SCOTT'S bore testimony to the great superiority of these magnets to similar magnets made by regular magnet makers in this country. But he had, after a series of magnetical investigations (the results of which he had published in 1843) made magnets nearly, if not quite, as powerful as those of M. Elias.

Mr. HUNT had tried magnetising by the coil, and found the best effect to be produced by a blue heat being given to the bar, which at that temperature was exposed to the current, and then plunged into water or a solution of ferro-prussiate of potash.

Dr. SCOTTESBY remarked that 500° or 505° was the best heat to which a bar should be raised before being magnetised. Too powerful magnets also ought not to be used in magnetising.

Mr. WARD had had considerable success in magnetising by the coil, by drawing a helix of about an inch in height from the centre of the bar, backwards and forwards, as in the ordinary mode of magnetising.

On a Tubular Crane. By Mr. FALCONER.—The jib and post of the crane is formed hollow, of boiler plate.

THE INSTITUTE OF BRITISH ARCHITECTS ON CEMENTS AND STUCCOES.

It is not often that the Institute of British Architects indulges in æsthetics. Generally speaking, when the subject is fairly opened to them by the nature of their lectures, they avert the discussion to a matter of fact question respecting the economical use of stone, the number of feet and inches in a broken column, or some other subject equally well calculated to promote an improved architectural taste.

With surprise and gratification, therefore, we observed that, during the late meetings, the reading of a paper on "Cements and Stucco" (*ante*, p. 221), led to an animated and interesting discussion respecting the legitimate use of those materials. The debate was carried on with far more earnestness of purpose than could be incited by a more abstract question. No abstract question can long engage the earnest attention of a general assembly, but to the British Architects the inquiry whether the use of deceptive materials be in good taste is not an abstract inquiry. It is a vital question to them; for probably if that question be decisively answered in the negative, it is not too much to assume that the decision would be condemnatory of half the buildings erected by members of the Institute.

Mr. KNOWLES, the reader of the paper referred to, states the objections against the use of stucco for "protecting and adorning the exterior of our buildings" to be

1. That cements and stuccoes are not durable, and require frequent and expensive repairs.
2. That they are very costly; not so much at first, as by reason of the colouring and painting in oil, which, it is thought (erroneously, as he believes), that they afterwards require.
3. That they are false and deceptive inasmuch as they, being artificially formed materials, do in some measure assume the appearance of natural productions.
4. That their introduction has led to all that is false in design, and defective in construction.
5. That when employed in decoration, the enrichments are deficient in that sharpness of outline and delicacy of finish by which the productions of the chisel are distinguished.

Of the first of these objections he confesses, that it applies with great force to modern London buildings, and that "extreme care" is required "in the construction of buildings intended to be covered with cement." The second objection may, he thinks, be removed by an improved knowledge of chemistry and geology. With respect to the deficiency of sharpness of outline in ornaments moulded in stucco, he asks whether it be not possible to overcome this difficulty by increased attention on the part of the architect in designing, and especially in inspecting the modelling of his enrichments whilst in the clay.

Up to this point we need not demur to any of the arguments in defence of stucco, for they amount to an acknowledgement, that the use of that material involves peculiar difficulties and requires peculiar precautions. But now comes the gist of the debate, the question as to the deceptive nature of the material. Mr. Knowles ingeniously argues, that grandeur, beauty, and originality of design, are far more important and far less easily attainable than costliness and durability of materials.

"That species of admiration which is excited by the costliness of the materials employed in works of art, has always appeared to me to partake considerably of the vulgar and the barbarous. For, as much as the heavens are higher than the earth, so much do I believe the emanations of the mind to be above and beyond the mere vehicle in which they are embodied."

Precisely. We do not happen to know the altitude of the "heavens," but if Mr. Knowles will adopt any kind of terrestrial measure, we have little doubt that we shall be able to assent to his estimation of the superiority of mind above matter. We readily allow that all that is vile and monstrous in taste may be exhibited in an arch of the purest statuary marble or bronze, cast in the most costly manner; while some of the most admirable buildings which have appeared on the face of the earth are churches and castles built of bricks. But who are those most liable to the charge of preferring the material before the design and skill of the architect? Those who would let plain bricks honestly show themselves? or those who would hide the bricks beneath a surface imitating costlier stone? The "admiration excited by the costliness of materials" does partake "considerably of the vulgar and barbarous." But can that vulgar and barbarous admiration be exhibited in a more vulgar and barbarous manner than in the concealment of cheaper substances by a more show and unreal pretence of costliness? Or can that same admiration be more openly and decisively disavowed than by the honest exhibition of the cheaper substances?

Mr. Knowles has, it appears to us, forged a weapon which inevitably recoils upon himself. His gun kicks more strongly than it shoots. The very argument which he has chosen for a defence of stucco is its most decisive condemnation. If the admiration of costly materials be barbarous, how infinitely more barbarous is the dishonest imitation of them. If the love of real gems has a vulgar taste, what shall be said of those who wear paste diamonds?

As a matter of practical experience, the use of stucco in domestic architecture leads to the constant re-production of the same insipid forms. Where the ornament can be laid upon a building as something altogether extrinsic and adventitious, the principal necessity for originality and invention is altogether evaded. But where the ornament is an essential and integral part of the building—where it depends upon, and springs out of, the construction, the architect is almost compelled to think whether he will or not; and, on the other hand, where the construction can be wholly hidden by a false surface, on which skin-deep ornaments can be laid at "so much per yard run," ornament becomes mere stock-in-trade, to be kept on hand till wanted, and the architect is superseded by the builder.

In the discussion which followed the reading of the paper, it is gratifying to find that architecture was regarded—not as a mere fancy or fashion—nor as a mere code of arbitrary rules—nor as a system of jugglery to delude men's eyes by false show of splendour—but as a liberal art. Mr. FRANKS appeared to us to give the *coup de grace* to the question, which the most unfortunate argument above referred to had already settled. Cement he considered "a material quite inadequate for the purpose of minute and elaborate design in ornamental work, which, when executed in it, must want the freedom of touch and the artistic feeling belonging to the chisel. For freedom of touch and artistic feeling, we should as soon look in a willow-pattern plate as in plaster ornaments run in a mould."

It is certainly in too exclusive a spirit that some writers condemn all kinds of ornamental forms multiplied by mechanical means. Such condemnation is far too general. It would include engravings which have a beauty and excellence of their own, differing much from that of the pictures from which they are taken. To engravings, moreover, is incontestably due the merit of popularising the highest works of the easel. But an engraver must be an artist, and have an intellectual feeling of the spirit of his original; while the maker of stucco ornaments is a mere mechanical drudge, an Irish labourer, probably, who has never cultivated his taste beyond an appreciation of gin and tobacco. The engraver must have a wonderfully keen eye for all the varying depths of different colours which have to be imitated by him by mere gradations of shade in black and white.

Even where mechanically produced, decorations require no tests for their successful reproduction, they may yet possess grace when honestly and legitimately employed. Such grace may and ought to belong to paper-hangings, the forms of porcelain, and glass utensils, and the patterns of the commonest and cheapest pottery. Such grace may also belong to ornaments of plaster properly employed. To confine ourselves to one instance among many, it would be, we think, mere architectural puritanism to object to the adornment of ordinary ceilings with appropriate decorations in stucco. In such use of plastic materials no deception could be intended or effected. The white plastered ceiling of an ordinary room can no more be mistaken for stone than ordinary gilding for gold.

The real offence against taste is the attempt to deceive. Gilding is a most admirable and beautiful species of decoration when legitimately em-

played; but when used where it passes for solid gold, it is the display of the vilest pretence. The similar observation applies with regard to stucco. As Mr. DONALDSON unanswerably observed, "the jointing given to cement in order to make it imitate stone, produces evidently a false appearance." It is a mere perversion of truth to say that no deception is meant in stucco-covered buildings, when pains are taken to score horizontal and vertical lines in imitation of the courses of masonry. How preposterous to allege that such a miserable expedient is not an attempt at deception! It has all the dishonesty of a juggle without its cleverness.

We would be almost content to leave the question on this single issue. When the admirers of stucco cease to score upon it the lines aforesaid, we will charitably try to hope that they intend no deception. But, until that be done, they will remain under the imputation of using a false substance to hide—not the poverty of materials—but, far worse, poverty of invention.

If we turn from mere speculation to the evidence of history, it is instantly apparent that those periods in which materials have been used honestly and faithfully, have been those least subject to that pest of architecture—copyism. The Greek temple, formed of solid blocks of stone was a purely original idea, entirely different from all preceding forms of architecture. The massive structures of Egypt and ancient Rome, with all their faults, bore the impress of unimitatable originality. Of the exhaustless fertility of invention, and the endless prodigality of design exhibited by our Christian ancestors, it is impossible to speak adequately. The proud Minster, the humble village Church, the impregnable Castle, and the graceful Hall, have each a distinct character of its own. But in our own time, all originality of design seems abandoned, or left to those few architects who build honestly. In domestic architecture, the highest effort is the reproduction of a well-known Italian facade, with a few slight variations, or the decoration of a building (of which the flat surface and vast rows of windows identify it in construction with a cotton-mill) with the endless repetition of heraldic devices and innumerable weathercocks. Ornamental architecture is worse even than this; for the new streets and charming villas which spring up like fungi about the metropolis, are generally more hideous than their vegetable types. It is a comfort to think that their defective construction promises an almost equally rapid decay.

We are earnest in the discussion of this question, and are willing to be charged with harping on one string till it is effectually set at rest, for we reckon among the most cheering signs of the progress of architecture, that those who debated the question at the Institute of British Architects were almost unanimous against the use of false materials. That pernicious system which insisted on us the gew-gaw splendour of Georgian taste, has too long cramped the energy and spirit of modern architects. The first promise of their emancipation from the insipid traditions of the last century, is coeval with the revived study of Pointed Architecture, a style which nobly evidences, that in building as in morals, it is good to be honest and true.

THE GREAT EXPLOSION AT SEAFORD.

TUESDAY was a blasting upon a large scale at Seaford on Thursday, 31st ult., for the purpose of throwing down a considerable portion of the chalk cliff on to the beach, for checking the progress of the shingle towards Beachy Head and the East.

Seaford is situated close to the eastern extremity of a bay three miles in length, extending from Seaford Head to Newhaven Head. It is one of the Cinque Ports. It is twelve miles from Brighton and about five from Beachy Head. Close to the sea is a Martello tower—the last westward; there is also a fort, which is under the care of a resident master gunner. But the ground about Seaford for two miles to the west lies low, and there is nothing to protect it from the inroad of the sea at high tides but a narrow beach bank of shingle. This barrier is becoming gradually weaker in consequence of the tendency of the shingle to drift away, and it has become a matter of urgent moment that this should be stayed. Close to Seaford, on its eastern side rises a noble line of cliff, in some places 300 feet high, and averaging above two hundred. It was determined to project a huge slice of the cliff to the beach, with a view thereby to constitute a groin for the purpose of retaining the shingle and preventing its leaving the bay. The operations have been conducted by the Board of Ordnance, but the owners of land about Seaford contribute towards the expense. The works were begun about seven weeks ago, and there have been 55 men of the Royal Sappers and Miners engaged upon them.

The spot selected for the operation is not much above half-a-mile

to the east of Seaford. At a height of about 40 feet above high-water mark there was driven into the cliff or excavated, a tunnel or gallery 70 feet long, 6 feet high, 3 feet broad, ascending with a slope of 1 in 3. At the inland extremity it turned right and left in the heart of the cliff, above 50 feet one way and above 60 the other, with a more gentle ascent, the two smaller galleries being 4 ft. 6 in. high, and 3 ft. 6 in. broad, and the three being in the form of a capital T. At the utmost end of each of the side or cross galleries was a chamber, 7 feet cube, lined with wood; and in each chamber a charge of no less than 12,000 lb. of gunpowder was deposited; making the distance of the centre of the charge 70 feet from the face of the cliff towards the sea, and about 70 feet above high-water mark. The galleries were "tamped," that is stopped up with bags of sand, and chalk in bags and loose, to within 50 feet of the mouth, both branches being tamped up, and 20 feet down the large gallery. The tamping is, of course, a very important matter; the hole through which the charge of powder is deposited should offer more resistance to the force of the exploded powder than the solid earth, in order that the powder may not find vent through that entrance, but spend its power upon the earth to be cast up; and this may be the better accomplished where the firing is by voltaic battery, because there is only a thin wire to pass through the tamping for the purpose of ignition. It must be added here, that above this charge of powder, and on the top of the cliff, three shafts or pits were sunk to the depth of 41 feet, and 600 lb. of gunpowder deposited at the bottom of each; these pits were tamped with chalk. Very near these pits—perilously near it almost seemed—about 180 feet from the edge of the cliff, a small wooden shed was erected, in which were placed three voltaic batteries, two of Groves's and one of Smee's, for firing the charges; the wires to convey the electric fluid to each charge were covered with tape and varnished or tarred over; the wires to the two lower charges in the chambers were of course, carried over the top of the cliff. It was arranged that these two great charges should be fired simultaneously, and the three above a few moments afterwards.

It was at twelve minutes past three o'clock, p.m. that suddenly the whole cliff, along a width or frontage of some 120 feet bent forwards towards the sea, cracked in every direction, crumbled into pieces, and fell upon the beach in front of it, forming a bank, down which large portions of the falling mass glided slowly into the sea for several yards like a stream of lava flowing into the water. The whole multitude upon the beach seemed for a few moments paralysed and awe struck by the strange movement, and the slightly trembling ground; every one sought to know with a glance that the mass had not force enough to come near him, and that the cliff under which he stood was safe. There was no very loud report; the rumbling noise was probably not heard a mile off, and was perhaps caused by the splitting of the cliff and fall of the fragments. There seemed to be no smoke, but there was a tremendous shower of dust. Those who were in boats a little way out state that they felt a slight shock. It was much stronger on the top of the cliff. Persons standing there felt staggered by the shaking of the ground, and one of the batteries was thrown down by it. In Seaford, too, three quarters of a mile off, glasses upon the table were shaken, and one chimney fell. At Newhaven, a distance of three miles, the shock was sensibly felt.

In a few moments after the cliff had fallen the crowd upon the beach rushed forward to it. A second fall of chalk, when they had got about half-way, checked them for an instant, and but for an instant. They rushed up the mound which the exploded chalk had formed. Although it is a mass of large rough stones for the most part, difficult in many places to climb except by using one's hands as well as feet, yet ladies eagerly clambered up it, and one gentleman managed to get his horse up. It will probably, like the cliff still standing, be rather unsafe for a time, as there is reason to believe that further falls will follow, considerable masses which have not yet fallen being evidently loosened. The mass which came down on Thursday is larger than was expected; it forms an irregular heap, apparently about 300 feet broad, of a height varying from 40 to 100 feet, and extending 200 or 250 feet or more seaward, which is considerably beyond low-water mark. It is thought that it comprises nearly 300,000 tons. The operation is considered to have been decidedly successful.

The work was under the direction of Sir J. Burgoyne, Inspector-General of Fortifications, but the immediate direction was taken by Captain Frome; Lieutenant Ward, R.E., had charge of the voltaic batteries, Colonel Lewis, Lieutenant Greston, and Lieutenant Crossman, assisted in the operations. Sir J. Reunie and a number of civil engineers were on the ground. Sir C. Pasley was present, and, as we understood, the Duke of Beaufort and

Lord F. Fitzclarence; as also was Mr. Wright, C.E., who conducted the operations at the blasting of Rounddown Cliff, near Dover; and Colonel Sandham, Sir H. Shiffner, and other gentlemen of eminence.

SMOKY CHIMNEYS.

Sir—If the following mode was adopted in building our fire-place openings and flues, we should require a much less number of those incongruous inventions at the tops of our chimneys, disfiguring as they do the sky-line of our houses. It has been successfully adopted by Mr. Pierce, of Jermyn-street, and ought to be generally known.



His plan is to fill-in the openings of old chimneys, and in building new ones, to contract them quickly though gradually, by means of a *convex gathering*, in contradistinction to the *concave*, which was formerly much in use. (It forms a quicker draft, and is not a receptacle for cold air, as the latter is.) I have tried it, and think it due to Mr. Pierce to say that it has fully answered. The diagram will illustrate it practically. The more perpendicular and central the flue is carried up for the first two or three feet before gathering over on either side, the more efficient will it be found. Let all bends be very easy, the flue of uniform size, with sound construction, and the fire-place openings proportionate to the size of the rooms.

I should observe that, gathering the flues over all in one direction, without returning them in an other, is now exploded. It is found to be quite immaterial as to where the flues go, provided all bends are easy.

JOHN BURGESS WATSON.

39, Manchester-street, Manchester-square.
Sept, 24th. 1850.

BUILDING BRIDGES IN THE AIR.

THE Academy of Sciences has at present under consideration a plan of a most extraordinary character, being neither more nor less than a suspension bridge between France and England. M. Ferdinand Lemaître proposes to establish an aerostatic bridge between Calais and Dover. For this purpose he would construct strong abutments, to which the platform would be attached. At a distance of 100 yards from the coast, and at distances of every 100 yards across the Channel, he would sink four barges, heavily laden, to which would be fixed a double iron chain, of peculiar construction. A formidable apparatus of balloons of an elliptical form, and firmly secured, would support in the air the extremity of these chains, which would be strongly fastened to the abutments on the shore by other chains. Each section of 100 yards would cost about 300,000*fr.*, which would make 84,000,000 for the whole distance across. These chains, supported in the air at stated distances, would become the point of support to this fairy bridge, on which the inventor proposes to establish an atmospheric railway. This project has been developed at great length by the inventor.

RHINE BRIDGE.—It appears from an official document published by Mr. Van der Heide, the Minister of Trade and Public Works, that the committee appointed to examine the merits of the various plans for a bridge over the Rhine, between the cities of Cologne and Deutz, have awarded the first prize of 250 *francs* d'or to Mr. John W. Schwedler, architect, of Berlin, and the second prize of 125 *francs* d'or to Captain Saurth William Morrison, of London, the engineer. There were several English competitors, among others Mr. Fairbairn.

ON GALVANIC SOLDERING.

In the 'Technologist' M. Elsner gives an account of some experiments he has made on galvanic soldering. Under the name of galvanic soldering, a process is known by means of which two pieces of metal may be united by means of another metal, which is precipitated thereon through the agency of a galvanic current. This mode of soldering by the 'wet method' has been often recommended in various periodicals relating to the industrial arts; but it has been objected that—practically speaking—the union between two pieces of metal could not be effected by means of a metal so precipitated by galvanic agency. In order, however, to arrive at a definite conclusion upon this question, M. Elsner undertook the following experiments, making use of a Daniell's 'constant battery.' The first experiment he made was by placing upon the end of the copper wire, which formed the negative electrode, a strong ring of sheet copper, cut asunder at one point, the distance between the severed parts being about one-half or one-third of a millimetre, and immersing it in a bath of sulphate of copper. At the end of a few days (during which time the exciting liquors were several times renewed) the space in the severed portion of the ring was completely filled up with copper regulus, which had been precipitated; and on partially cutting with a file through the part thus filled up, and examining it with a lens, it was observed to be very equally filled with solid and coherent copper. A second experiment was made with another copper ring cut into two parts, and the two segments placed with the faces of the sections opposite each other, and similarly submitted to the action of a galvanic current. At the end of a few days the segments were united by the copper precipitated, and again formed a complete ring. A third experiment was made by placing two strong rings of sheet-copper, with their freshly-cut faces upon one another, so that the two rings constituted a cylinder. These rings were surrounded by a band of sheet-tin, coated with a solution of wax, so that the two rings were equally surrounded by a conducting material. The rings were then attached to the negative wire of the battery, and immersed in a bath of sulphate of copper. At the end of a few days the interior surface and the contact surfaces of the two rings were covered with precipitated copper. The rings were only submitted to the galvanic current to such an extent as to cover their interior surface with a thin coating of precipitated copper, and yet they were so completely re-united that they formed a single cylinder. The exterior conducting covering of tin was, of course, removed, before testing the cohesion of the galvanic precipitate.

From these experiments, there appears to be no doubt that two pieces of metal may be firmly united or soldered by galvanic agency. It will, therefore, be possible to firmly unite the different parts of a large piece of metal, and to make a perfect figure of them by galvanic precipitation of a metal (copper in ordinary cases.) If solutions of salts of gold or silver were employed in as concentrated a form as those of copper above-mentioned, there is reason to believe that galvanic soldering would also result. In fact, M. de Hackewitz states, that in some experiments on a larger scale, which he undertook, to obtain hollow figures by galvano-plastic means, he had remarked that galvanic union often took place between the pieces operated upon. M. Elsner states, that while conducting the experiments above-mentioned, he remarked that, by employing too powerful a current, the negative electrodes of copper, and even the plate of copper, and ring of the same metal resting thereon, became covered with a deep brown substance, in the same manner as this occurs under similar circumstances in galvanic gilding, as is well known. After several unsuccessful attempts to prevent the formation of this brown coating, M. Elsner found that it was possible to remove it entirely on immersing the articles covered therewith, during a few seconds, in a mixture of sulphuric and nitric acids. By this means the precipitated copper was made to assume its natural red colour.

With respect to the cohesion of the galvanic soldering, it is the same as that of copper or other metal precipitated by galvanic agency. It will, moreover, be well understood, that too energetic galvanic excitation must have an injurious influence upon the cohesion of the metal precipitated; and in this case precisely the same phenomena will be observed as those which have long manifested themselves in ordinary galvano-plastic operations.

THE QUARRY OF THE LIVERPOOL DOCKS.

Kilmabreck Quarry is the source whence all supplies of granite blocks and paving stones for the Liverpool Dock Quays are derived. Kilmabreck is situate near Blackornig, in Galloway, and has of late years become a place of some importance. The quarry was opened about twenty years ago; and the clergyman of the parish gives the following interesting description of the *modus operandi*:—"The working of this quarry, in 1854, cost nearly £5,000, including rent and tonnage of vessels, &c. It is wrought in three breasts, about 30 feet high each, the one above and behind the other. The operations are conducted with much skill and regularity. At one time powder was very much employed in this work; fifty, sixty, and as high as seventy pounds were used in one blast. These explosions were felt and heard at a considerable distance, as the slight shocks of an earthquake. The use of powder, however, except in opening up corners, has been for some time entirely given up. Blasting was found to shake and frequently to destroy some of the finest blocks. Drills, wedges, crowbars, sledge-hammers, and cranes, are now principally used in quarrying even the largest masses; and it is truly astonishing to see with what facility even mountains can be removed by handiwork. In the quarry the rocks are stratified. The strata are perpendicular, and vary in thickness from nine inches to five feet. When a mass is to be separated, wedges are introduced between the strata, and are driven down with sledge-hammers until a separation is effected. A large crow-bar, well manned, is then applied, to throw down the mass to the bottom of the quarry. This accomplished, the next thing is to cut up the stone into blocks as large as the materials will admit of; and this part of the work is, perhaps, the most interesting process of the whole. The rude and unsightly mass may be five feet thick, and ten or twelve feet long, and must be cut into the form of a parallelogram, to fit with mathematical precision in its own appointed place in the docks. Holes are bored four or five inches deep, with a drill or jumper, and eight or nine inches apart, in the line the stone is to be split. A block of fourteen tons is soon cut to the size and shape required by the power of 'the plug and feather.' When a hole has been bored of the required depth, two wedges are introduced into the hole, with the thick end down, and by driving the one down into the centre, the combined power of three wedges in this position, and made to bear upon every hole, and thus split the stone. A few holes charged with plug and feather will be found sufficient to split a very large stone. In splitting granite in this way, the quarrymen are careful to place the holes and the wedges parallel with the grain of the stone. This arrangement renders the process comparatively easy; and the skilful workmen can shape their blocks and paving stones with as much comfort as if they were cutting wood in a saw-mill. As a proof of the extraordinary power of the 'plug and feather,' it may be stated, upon the authority of the present skilful overseer, that masses of 500 tons are sometimes lifted or removed by their aid. There is a comparatively narrow ridge of granite rock running parallel with the shore from Croxtown to the entrance of Fleet Bay, and which is probably connected with the great mass of the same formation of which Carrasmore forms the western side, though divided on the surface by a stratum of greywacke. The situation of the quarry has thus been well chosen; for the blocks, when cut and shaped, are transported by a short railway to the shore below, and there shipped in vessels belonging to the Dock Trustees, who have a little fleet of what are called 'stone boats,' continually sailing betwixt Wigton Bay and the Mersey.—*Liverpool Chronicle*.

ON FARM BUILDINGS.

A very valuable improvement has been lately suggested in the erection of farm buildings, that the whole area be roofed over like the terminus of a railway. This idea is very little known, and will, no doubt, have to contend with much opposition. It will protect the animals, prevent the heavy rains from injuring the dung, and protect the manure from being dried on the surface by the hot suns of the early summer. For such roofs, corrugated iron is the most proper, as its own strength will stand over a moderate width, and it does not require any supporting substance on which to be laid. The asphalted felts are combustible, and require a wooden roof, on which they are fixed, and on both these points they are inferior to the corrugated iron. The three wings of the farmery will be roofed over with this thin iron, at the common elevation. In covering the width of 20 feet over walls, three rows of roofing will cover the interior of the farmery, and may range north and south, and will rest on cast-iron pillars, which are placed in the subdivision walls of the feeding yards. The roofing can extend over the rickyard and the railway, and place all under one roof. If agriculture would look to the mighty, and at the same time the very convenient joint performances of machinery and railways, it would quickly perceive that many useful modifications of their utility might be introduced into the practical operations of its own departments. It may be very reasonably proposed, that all the articles of agricultural produce, which are changed in form for the purpose of being used, should be placed on the second floor of the farmery, or carried to it, and hence let down in the prepared form to the places where they are wanted. When it is preferred to cut the turnips into slices and the hay into chaff, and when

the incontestable improvement comes into use of cutting all straws that are used for litter—then it is evident that all the articles in the crude form must be placed on the higher floor, and descend from it in the prepared condition. In the improved use of threshing machinery, the unthreshed grain is raised from the ground-floor to the feeding board by means of a travelling carrier that is driven by the machinery; or it may be carried from the ricks to the second floor on a high railway, that is placed to the necessary height. The grain from the ricks is laid upon a light wagon, which runs upon the railway to the feeding board. The power of steam will drive machinery to almost any extent; and cutters may be placed on both sides of the engine for the purpose of cutting the straw, hay, and roots. The straw may be taken as it falls from the shakers, and put into the adjoining cutters of the kind to cut it into lengths of 3 or 4 inches for the purpose of litter. The hay may be cut into chaff by cutters closely adjoining. On the other side of the engine the roots may be cut by a similar application; and can be raised to the box of the knives by a narrow travelling carrier from the ground floor, and in quantity as the cutters are able to manufacture. The cut food may be laid in stores, whence it can be carried in light wagons on railways to the required places, and let down in spouts. The railways for this purpose must run to the necessary positions for feeding cattle and horses, and for strewing litter over the yards. It is a good thing to have a railway on the ground between two rows of ricks, on which a wagon conveys the grain to the lower floor of the barn, whence a travelling carrier raises it to the second floor, where the machinery receives it to be scutched. A suggestion not much different, places the railway between the rows of ricks on cast-iron pillars, that stand at the height of the second floor of the machinery, and on which the grain is carried by a wagon to the feeding board. A third idea may be published, that the ricks of grain stand singly on four-wheeled platforms resting on a branch railway at a sharp angle of divergence with the main trunk, which leads to the threshing barn. When the rick is wanted to be threshed, the platform is run along the railway which inclines gently to the barn, where an outside shed receives the rick under cover from rain, during the time of threshing. The barn stands across the railway, and receives the rick without the labour of turning such a heavy body to a cross direction. The platforms are returned to the position on the branch railway, in order to receive a rick of the next year's growth. The ricks and machinery are covered by the corrugated iron roof of the farmery extending over them. The suggestion of having a second floor over the entire area of farm buildings, on which to perform all the manufacturing work in the preparation of the different articles for use, may be reckoned a chimera, or a wild rally of the imagination, and with it will be chased the idea of placing each rick of grain upon a four wheeled platform, and running them entire to the barn, as each may be required to be threshed. But from a due consideration, there certainly appears nothing improbable in the feasibility of its adoption, and nothing impossible in the application and execution of the various parts of the composition. It is only an extension of the principle that has already been used on a minor scale and for smaller purposes.—*Gardener's Chronicle*.

NOTES OF THE MONTH.

NEW PORT IN THE MEDITERRANEAN.—The *Constitutionnel* contains the following:—"Bastia is the wealthiest and most populous town in Corsica. Situated opposite to the Gulf of Genoa, within a few hours' journey from the coasts of Italy and France, on the road to the Adriatic, Sicily, and the Levant, it has become the most important centre of traffic in the country; and of itself possesses one-fourth of the navy. Struck with this importance and with the insufficiency of the old port, the government applied for a credit of 3,000,000*fr.*, with the addition of a subvention of 500,000*fr.* furnished by the town of Bastia for the construction of a new port. The works are now in active progress. The port will be of vast dimensions. It will inclose a surface of more than 12 hectares (30 acres), one-half of which will present a depth of 6 metres (19 feet), and of which 2 hectares at least will afford a depth of more than 8 metres (26 feet). A mole in the direction of north to south will shelter the port on its widest side. A refuge will thus be created from the most dangerous storms of those seas, not only for trading vessels of the largest tonnage, but also for the war navy, an important result upon a coast which, for an extent of 40 leagues from the Cape Corse to Porto Vecchio does not afford a single harbour of refuge."

RAILWAY STATION.—Although there is a station at Chester 1000 feet long, and which cost 100,000*l.*, defrayed by four companies, the London and North-Western have decided upon a separate establishment in consequence of the annoyance and litigation attendant upon their present locale. A depuration of the directors has chosen the site, and plans and estimates are being prepared. We have not heard whether Mr. Phillip Hardwick is to contribute the architectural features, but we presume they will be under his charge as the Company's architect.

HEATING HORTICULTURAL BUILDINGS.—The following is recommended as an economical, efficient, and simple mode of heating:—"I have been constructing a furnace, with a brick flue four-brick high and sixteen feet in length. This is covered over with tiles an inch and a half thick. The other part of the flue is continued with bricks on edge, covered over with common tiles on the top of the flue; I have made a trough or gutter for the water to flow in. The apparatus is fixed in the furnace containing only five quarts of water, but the trough or gutter will hold twenty gallons, which I find gives a very powerful heat, and will maintain the heat a considerable time, which is a great consideration in cold weather. There is no boiler or iron pipes or tanks used in this plan. The furnace is so constructed that any old cinders will keep a good fire. The Polmaise system can be used at the same time, but I don't want it. This is not upon a large scale, as the flue and return trough or gutter is only about forty feet. It is only the simplicity of the plan which induces me to forward you the above short sketch."—J. D. *Gardener's Journal*.

Gas Baths.—The gas baths constructed by Messrs. Desires and others, are now attracting much attention, as affording the ready means for architects and builders to provide bath accommodation in private houses, for which there is a growing demand on the part of the public. With the cheap supply of gas throughout the country, many new domestic arrangements will be made, particularly simple means of cooking in summer time; and in large establishments gas cooking apparatus is likely to be applied, as giving great power in a small space.

THE RAILINGS FOR THE BRITISH MUSEUM.—A report is current that the iron railings for the extensive front of the new buildings of the British Museum are to be cast in France. The reason for this is said to be the admiration which is justly expressed for the iron railings in front of Mr. Hope's house in Piccadilly, which were made in Paris, and which are distinguished for sharpness and fineness in casting. It is, however, extremely unjust to rate French casting above English on this account. Mr. Hope's railings cost upwards of thirty shillings per cwt.; whereas the common contract price under competition for similar work in England is twelve shillings per cwt.; and it is with work of this price that Mr. Hope's railings are compared. Let the trustees of the Museum offer even two-thirds of the price that was given by Mr. Hope, and they will find plenty of English manufacturers who will produce railings quite equal to the fancy-price foreign article in Piccadilly.

PORTSMOUTH.—Another dock, the ninth now in this dockyard, was added on the 24th ult. to this establishment. The dock was opened at noon by the floating in of H.M.S. *Neptune*, of 120 guns, in the presence of a very large concourse of officers and visitors. This addition renders Portsmouth more complete for dock accommodation than any other naval establishment. The following are the dimensions of the structure:

	ft.	in.
Length from the centre of the main groove to the head	308	0
Breadth of the floor	200	0
Breadth between the coping	192	0
Breadth of the entrance	55	0
Depth from the coping to the floor	25	4
Depth of the dock	27	0

It is built of Cornish granite upon a pile foundation, and framed grillage brackwork on cement under the floor. The following are the chief items used in its construction:

Mr. Barker, in piles and sleepers, 54,000 cubic feet.
Br rough and cast-iron, 95 tons.
Concrete, 1,500 cubic yards.
Bricks, 2,022,000.
Granite, 132,400 cubic feet.
Purbeck stone, 14,000 cubic feet.
Portland stone, 35,000 cubic feet.

Capt. James, R.E., and Mr. H. Wood, clerk of the works, are the officers under whose superintendence the dock has been built, which adds another to the several national works contracted for by Mr. B. Bramble, the surveyor of Portsmouth.

HARTLEPOOL.—The annual meeting of the Hartlepool West Harbour and Docks Company was held at West Hartlepool, on the 5th. The report referred to the proceedings in the last session of parliament, and to the act obtained for powers to enlarge the West Harbour, by so altering the piers and enclosing a further part of the sea shore as would give an additional space of sixteen acres. The proprietors readily resolved upon commencing these works, and completing them with all practicable expedition. The West Harbour will then contain an area of about forty-four acres, and will be the largest pier harbour between London and Leth. It will be capable of sheltering 200 to 300 ships, in addition to the accommodation afforded by the two docks, which will contain about twenty acres. The works of the second dock were reported to be in a very forward state, the excavation being more than half finished, and about two-fifths of the dock walls completed. The new town of West Hartlepool, surrounding the West docks, is progressing very rapidly, the company having sold land for about 160 houses within the last ten months. It is calculated that after deducting a moderate valuation of the land available for resale, the total expenditure on all the works will be about 800,000l., which will represent an undertaking consisting of a harbour of about forty-four acres, two docks of about twenty acres, together with all the land specially appropriated for them, and shipping staiths, approaches, quays, dock and merchants' offices, and various other buildings and working stock and establishment.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM AUGUST 22, TO SEPTEMBER 26, 1880.

Six Months allowed for Enrolment unless otherwise expressed.

- William Dick, of Edinburgh, professor of veterinary medicine, Veterinary College, Edinburgh, for improvements in the manufacture of steel and gas.—August 22.
- Benjamin Betch, of Lowlands, Middlesex, Esq., for a facitious salt-petre, and a mode by which facitious salt-petre may be obtained for commercial purposes.—August 22.
- William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in refining gold. (A communication.)—August 22.
- William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the construction of ships' magazines. (A communication.)—August 22.
- William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery or apparatus for producing ice, and for general refrigerating purposes. (A communication.)—August 22.
- William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in the construction of ships or vessels, and in steam boilers and gas-engines. (A communication.)—August 22.
- Daniel Dillingworth, of Bradford, Yorkshire, worsted spinner, for certain improvements in machinery for preparing all descriptions of wool and hair grown upon animals, for the carding, combing, and other manufacturing processes.—August 22.
- Duncan Bruce, of Pangeble, Gaspe, Canada, but at present at Liverpool, Lancashire, Esq., for certain improvements in the construction of rotary engines.—August 22.
- Richard Prosser, of Birmingham, civil engineer, for improvements in supplying steam, boilers with water, and in clearing out the tubes of steam boilers.—August 22.
- Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in cutting types and other irregular figures. (A communication.)—August 22.
- George Augustus Huddart, of Brynkr, Carmarvon, Esq., for certain improvements in the manufacture of cigars, and certain improved apparatus for smoking cigars.—August 22.
- Sir John Scott Lillie, Companion of the most Honourable Order of the Bath, of Paris, France, for certain improvements in the application of motive power.—September 5.
- John Saul, of Manchester, cotton spinner, for certain improvements in machinery or apparatus for spinning and twisting cotton and other fibrous substances.—September 5.
- George Smith, of Manchester, engineer, for certain improvements in steam-engines, and also improvements in feeding or supplying the boilers of the same, part or parts of which improvements are also applicable to other similar purposes.—September 5.
- William Watt, of Glasgow, North Britain, manufacturing chemist, for certain improvements applicable to inland navigation, which improvements or parts thereof, are also applicable generally to raising, lowering, or transporting heavy bodies.—September 5.
- Andrew Barclay, of Kilmarnock, Ayr, North Britain, engineer, for improvements in the smelting of iron and other ores, and in the manufacture or working of iron and other metals, and in certain rotary engines and fans, machinery, or apparatus as connected therewith.—September 5.
- William Erskine Cochran, of Cambridge-terrace, Regent's-park, and Henry Francis of Prince-street, Rathfriland, for improvements in propelling, steering, and ballasting vessels, in the pivots of steam-engines, in the bars of furnaces, and in sleepers of railways.—September 5.
- Frederick Woodbridge, of Old Gravel-lane, Middlesex, engineer, for improvements in machinery for manufacturing rivets, bolts, and screw blanks.—September 5.
- John Beattie, of Liverpool, engineer, for certain improvements in steering vessels.—September 5.
- James Mathier, the younger, of Crow Oats, Pilkington, Lancashire, bleacher, and Thomas Edmondson, of the same place, calenderman, for certain improvements in machinery or apparatus for scouring, finishing, and stretching woollen, cotton, and other woven fabrics.—September 5.
- Christopher Cross, of Farnworth, near Bolton, Lancashire, cotton spinner and manufacturer, for certain improvements in the manufacture of textile fabrics; also in the manufacture of weaving apparel and other articles of textile materials, and in the machinery or apparatus for effecting the same.—September 5.
- James Rennie, of Coward Bank, Falkirk, Stirling, Scotland, gentleman, for a certain improvement or improvements in the construction of gas retorts and furnaces, and in apparatus or machinery applicable to the same.—September 5.
- Pierre Brand, of Paris, for improvements in the construction of pianofortes.—September 12.
- Robert Longdon, the younger, of Derby, glove manufacturer, and Thomas Parker Tabberer, of Derby, manufacturer of elastic fabrics, for improvements in the manufacture of leopet fabrics.—September 12.
- Astley Foston Price, of Margate, Kent, chemist, and James Heywood Whitehead, of the Royal George Mills, Saddleworth, near Manchester, for improvements in filters.—September 12.
- Thomas Lucas Paterson, of Glasgow, North Britain, manufacturer and calico printer, for certain improvements in the preparation or manufacture of textile materials, and in the finishing of woven fabrics, and in the machinery or apparatus used therein.—September 12.
- Richard Archibald Broome, of the firm of J. O. Robertson and Co., of Fleet-street, London, patent agent, for improvements in purifying water, and preparing it for engineering, manufacturing and domestic purposes. (A communication.)—September 12.
- Robert Jeremy Christie, of Paris, engraver, for improvements in cylinder printing.—September 12.
- James Wheeler Rogers, of Dublin, civil engineer, for certain improvements in the preparation of peat, and in the manufacture of the same into fuel and charcoal.—September 12.
- William Eccles, of Walton-le-dale, Lancashire, cotton spinner, for certain improvements in looms for weaving.—September 12.
- Samuel Reibang, of Manchester, pattern maker, for certain improvements in looms for weaving.—September 12.
- John Neumyth, of Partick, Lancashire, engineer, and John Barton, of Manchester, copper roller manufacturer, for certain improvements in machinery or apparatus for painting calicoes and other surfaces; and also improvements in the manufacture of copper, or other metallic rollers to be employed therein, and in the machinery or apparatus connected with such manufacture.—September 12.
- Henry Houghworth, of Cottage House, Lanark, North Britain, iron-master, for improvements in the manufacture of iron and other metals.—September 20.
- Alfred Vincent Newton, of Chancery-lane, mechanical draughtsman, for improvements in dyeing yarn, &c., in manufacturing certain woven fabrics. (A communication.)—September 20.

LECTURES ON THE HISTORY OF ARCHITECTURE,

By SAMUEL CLEGG, JUN., M.A.C.E., F.C.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF SUCCEDECH, &c.)

Lecture X.—ROME.

Roads—Aqueducts—Fora—Basilica—Amphitheatres—Circi
Theatres—Thermae—Triumphal Arches.

Dionysius of Halicarnassus says, that "of all the monuments of Rome, the three that appeared to him the most to proclaim the power and magnificence of Rome, were the great roads, the cloacas, and the aqueducts." In the two former works, the Romans only imitated the example of their Etruscan teachers, though they carried them out to an extent commensurate with the vastness of their dominion. The Roads, or Vias, traversed, like great arteries, all the provinces of the empire; extending from point to point in nearly a straight line, regardless of "engineering difficulties." Mountains were tunneled, and magnificent bridges thrown across the widest rivers. The bridge constructed over the Danube by command of the Emperor Trajan, consisted of twenty arches, each 170 feet span; the piers were 150 feet in height from the foundation, and the roadway 60 feet in width. Eight bridges led across the Tiber to the different roads out of Rome. The bridges were frequently decorated with niches and statues in the piers, and often were entered through triumphal arches, or protected by towers. In forming the roads, after the ground had been properly levelled, a mixture of small stones and puzzolano was laid to a certain depth; and on this were placed closely-fitted polygonal blocks; where the blocks were defective, the interstices were filled in with flints, and in some instances with wedges of granite, or metal; producing, on a horizontal plane, the appearance of a Pelagian wall. The road was divided into three parts, the foot-way occupying the centre; this was raised above the carriage-way, and was somewhat broader; it was protected by upright stones placed at intervals, some being higher than others to assist the passengers to mount on horseback, the Romans using no stirrups. At the end of each mile was a stone inscribed with the number of miles from Rome, measured from the Columna Milliaris, in the Forum Romanorum. Every five or six miles, post houses were erected, each of which was to be provided with forty horses. Of such importance was facility of transit considered, that men of the highest rank were appointed to superintend the preservation of the public roads: Augustus himself was at one time surveyor of a district.

The Romans were probably the first builders of Aqueducts; for though the Etruscans excelled in tunnelling and draining, there is no record of any aqueduct (as the term is generally understood) before the time of the Roman republic. So necessary was it thought to have a plentiful supply of fresh water, that no expense was spared to obtain it. Water was conveyed from springs forty or even sixty miles distant; and in the most flourishing period of the Empire, forty streams flowed into Rome through fourteen aqueducts. Pliny says, speaking of the aqueducts, "If any one will diligently estimate the abundance of water supplied to the public baths, fountains, fish-ponds, artificial lakes for galley fights; to pleasure-gardens, and to almost every private house in Rome; and will then consider the difficulties that were to be surmounted, and the distance from which these streams are brought—he will confess that nothing so wonderful as these aqueducts is to be found in the whole world."

Some idea may be formed of the expenditure lavished upon an efficient water supply, from an application made by Herodes Atticus to the Emperor Hadrian, for 300 myriads of drachms for the purpose of bringing a stream of fresh water to the city of Tross in Asia Minor; at the same time reminding the Emperor that he had granted larger sums to much less important towns. Hadrian complied with the request; but when the aqueduct was finished, the expense was found to have exceeded 700 myriads; whereupon the munificent Herodes himself presented the extra sum to the city: 500 myriads amounted to about 161,458*l*.

These noble structures were erected wherever the Roman power extended. They were either single, with one row of arches, like the Aqua Marcia at Rome; or in a double row, one over the other, like that at Segovia; or even triple, like the celebrated Pont du Gard near Nîmes. This great aqueduct extends between two mountains, and crosses the river Gardon, which passes under the

fifth arch; it is about 907 feet in height. The source of the Aqua Claudia at Rome, is 46 miles distant; the walls for ten miles were raised on arches, and some of which arches are 100 feet in height. The Romans gave a considerable inclination to the water-courses, and caused them to deviate from the straight line, in order to check the rapidity of the current. In some instances, the water was filtered through gravel laid for that purpose in the channel.

The Reservoirs, or Castelli, into which the aqueducts poured their waters, were of great capacity, and frequently elegant in design and decoration; one is described, built by Augustus, at Nicopolis, as a large oblong building, at each end of which was a reservoir fed by the aqueduct of the city; round the interior of the building were niches, where stood marble statues of naiads, holding shells, from which the crystal stream overflowed into the castellum. Thus did this luxurious people combine utility with beauty.

In viewing the ruins of Rome, the observer cannot fail to be struck with the magnificent remains of the ancient Fora. These, like the Agora of the Greeks, were the great centres of business: they were open spaces, oblong in form, surrounded by porticoes and other public buildings, and adorned with altars, columns, and statues. They were of two kinds, the Fora Civilia, and the Fora Venalia; the former appropriated to the transaction of public business, the latter to the holding of markets. The surrounding porticoes were two stories in height, the lower serving as the offices of bankers and merchants, the upper for the populace assembled to witness the gladiatorial combats, which were exhibited in the forum before the erection of the amphitheatres. There were only two fora at Rome before the time of Augustus, who laid out a third; others were afterwards added by succeeding emperors. The principal, both in extent and importance, was the Forum Romanorum; which, amongst other public buildings, contained the Julian Basilica, the Curia Julia, where the senate held its sittings; and the temples of Castor and Pollux, and Jupiter Tonans. In this forum was the rostrum from which orators addressed the people: it received its name during the time of the Commonwealth, from being decorated with the prows of vessels taken from the enemy. The ruin of the great Forum Romanorum is so complete, that its very limits are a matter of discussion: its present name, Campo Vaccino, or bullock-field, describes its degraded state.

The Fora of Julius Cæsar, or Augustus, and of Trajan, were all celebrated for their architectural magnificence; the latter was entered by four triumphal arches, and in the centre stood the beautiful Trajan column, designed by the architect Apollodorus. This column, of the Tuscan order, is 12 ft. 2½ in. lower diameter and 97 ft. 8 in. in height; the bas-reliefs with which the shaft is covered ascend in a spiral line from base to summit; within, stairs leading to the top are cut in the solid marble. It stands upon a lofty pedestal, ornamented with eagles, crowns, and other insignia: the ashes of the great Trajan are said to repose beneath. Part of a hill had to be cut away to afford room for the Forum Trajani, and the height of the column denotes the depth of the excavation. The Antonine column is nearly a copy of this; but as the shaft is nearly parallel, it is inferior to it in elegance.

The Curia and Basilica were always situated in or near the Forum; the former were places of assembly. Vitruvius recommends that in the Curia, the walls should be intersected by a cornice, to be continued round the interior, half its height from the floor; "for without this precaution, he says, 'the voices of those who are debating, would ascend to the upper part of the court, and be lost to the audience. But when cornices are introduced, and continued along the walls, the sounds will be interrupted in their ascent, and be distinctly heard before they are dispersed in the air.'"

The Basilica was a building adapted to the two-fold purpose of the meeting of merchants, and the administration of justice; it was of oblong form, divided by rows of columns into three, or five aisles; the longitudinal aisles were terminated by another in a transverse direction; here waited the advocates, notaries, and all those who were engaged in prosecuting causes. Opposite the central aisle, this division, or transept, projected out in a semicircular recess, raised a few steps, so as to form a kind of dais. This part was called in Greek *agora*, and in Latin *tribuna*: here sat the prætor with his assistants; and from this courts of justice have been called Tribunals. The longitudinal aisles were used by the merchants as an exchange; the central one was two columns in height, the upper row forming a kind of gallery. The aisles were covered by a flat ceiling; the tribuna with a semi-dome, or conch. The basilica presented a plain exterior, the decoration

being within; the tribuna was the most highly ornamented part; it is uncertain whether the aisles were inclosed by walls, or whether only by arcades opening into the forum. There were also other apartments, called *chalcidicae*; but for what purpose is unknown. Some suppose them to have been store-houses for the corn to be distributed to the populace; as, according to Varro, the *creta chalcidica* had the property of preserving grain; but this is mere conjecture—the term *chalcidica* is employed by some authors to signify all the rooms in the upper part of the house, generally used as store-rooms.

Leaving the buildings appropriated to business or utility, we now come to those set apart for entertainment and luxury; the most important and characteristic of which is the Amphitheatre, giving proof both of the wealth and power of the mighty Roman people, and of their ferocious and sanguinary disposition.

We have already traced the Amphitheatre to an Etruscan origin; the name first given to this kind of structure in Rome was *Theatrum Venatorium*, or theatre for hunting. During the Commonwealth, the gladiatorial games were generally exhibited in the forum, no permanent amphitheatre then existing. It is supposed that these games or combats were first celebrated at funeral feasts; but finding them so agreeable to the populace, those advanced to high offices in the state were accustomed to give them as bribes or rewards at their election, hence they were called *donations*. Gladiatorial shows soon became a passion with the people of Italy, and were encouraged as a means of exciting a fierce and warlike spirit; even Pliny the younger speaks of these games as proper to inspire fortitude, and to make men despise wounds and death. The first public show of wild beasts was on occasion of the victory obtained over the Carthaginians by Lucius Metellus, when the captured elephants were driven round the arena by slaves with blunted javelins, in order to dissipate the fear inspired by these strange and enormous animals. Wild beast fights do not appear to have been introduced till after the second Punic war. The amphitheatre was at this time only a temporary structure of wood, erected in the Campus Martius, and removed at the conclusion of the games. It is said that Caius Curio, tribune of the people in the time of Cæsar, gave an entertainment on his father's death, causing two theatres of wood to be constructed for the morning representations of the drama; these theatres were so contrived, that in the afternoon the semicircles were swung round, and made to meet at the extremities so as to form an amphitheatre for the exhibition of gladiators, with which the sports of the day terminated. The first permanent amphitheatre was built by Statilius Taurus, in the 725th year of Rome; this was a stone edifice, but of small size. As the degradation of the lower classes increased with the absolutism of the emperor, so the craving after these murderous games increased also; the populace of Rome were little better than a multitude of paupers, receiving their daily bread from the public stores, and *panem et circenses* became the popular cry. Perhaps it was found by their tyrants, that the exhibition of public games was an easy way of keeping the people quiet, by affording a safe vent to their love of excitement; but be this as it may, the old amphitheatre was found quite inadequate to contain the crowds that flocked to witness the shows, and in the reign of Vespasian, the great amphitheatre was founded, called the Flavian, from the name of the Emperor Flavius Augustus. It was completed by his son Titus, some authors say in three, others in ten years; many thousand slaves were employed in its construction. This enormous building is generally known as the Coliseum, either from its gigantic dimensions, or from a colossal statue of Nero that stood near. It is elliptical in form, 680 ft. in length, by 513 ft. in breadth, and is 157 ft. in height; it occupies six acres of ground, and was capable of accommodating 80,000 spectators.

The Roman amphitheatres and theatres are architecturally interesting, as affording the earliest examples of the use of orders one over the other on the exterior. The Coliseum has four stories, the three lower consisting of arcades, separated by piers and engaged columns; the upper, of an attic pierced with windows, the piers being decorated with pilasters. The lower order is Doric, the second Ionic, and the third Corinthian. Those who have examined the building disagree as to whether the upper order is Corinthian or Composite; Serlio, Taylor, and Grey stating it to be Composite; and Palladio, Cipriani, Deaguetz, and others, Corinthian. As the wall of the building ascends, it gradually tapers inwards; the diminution in its thickness is given to the exterior, the interior face being vertical; this tendency to the pyramidal form greatly adds to its apparent solidity. In the two lower orders, the columns project more than half their diameter;

in the third, exactly half. The Doric columns are upwards of nine diameters in height, and are raised on pedestals; the entablature is not quite one-fourth the height of the column; the frieze is plain, without triglyphs; the width of the piers is rather more than half the aperture of the arch, and the thickness nearly the same. The upper stories being so far removed from the eye, the capitals of the columns present mere indications of the order to which they belong. The lower arcade consisted of eighty portals or vomitories, numbered like the boxes of a theatre. The lower story was occupied by five corridors; from the second and third were the staircases giving access to the upper seats; from the fourth, a flight of marble steps led to the podium. There were four principal entrances, 16 ft. 4 in. in width; the other arches being only 14 ft. 6 in.; that to the north was the portal by which the emperor entered from his palace on the Esquiline. The interior central space was covered with sand, to absorb the blood of the victims; hence it was called the "arena." From this rose the podium, a wall 12 feet high and 14 feet broad, protected from the springs of the wild beasts by a small canal and a spiked railing; on the podium were the seats for the emperor, senators, foreign ambassadors, the vestal virgins, and the editor, or person who gave the games. The equites sat in fourteen rows above. The emperor's seat was raised, and was hung with silken draperies like a pavilion. Ranges of marble seats then rose one above another to the upper story, where wooden benches served to accommodate the lower ranks of spectators. Doors opened on to the arena below the podium, through which the gladiators and beasts entered; and the bodies of those butchered in the games were dragged out by a hook, into the *spoliarium*. Cells or chambers, have been discovered beneath the arena, which some have supposed to have been dens for the beasts; but it is uncertain whether the vivarium was contained within the walls of the amphitheatre; they were more probably used for the machinery necessary to the changes of scene produced on the arena. It was occasionally filled with water, for the representation of sea-fights; and sometimes trees were transplanted there, and artificial caves and rocks formed, amongst which the wild beasts lurked as in their natural state. During the work of slaughter, the audience were refreshed with jets of odoriferous water, rising into the air and dispersing like small rain; and were sheltered from the sun by an awning or *velarium*. Over the windows in the upper story are corbels, for the purpose of attaching the masts of the *velarium*, which passed through holes perforated in the cornice. The *velarium* was in six parts, drawn together by cords; it was generally of woollen cloth, but on particular occasions of embroidered silk. We are informed that the net-work before the podium was of gold wire, and the fascine of the benches ornamented with mosaic work of precious marbles; and that on high festivals the furniture of the amphitheatre was entirely composed of gold, silver, and amber. According to Martial, people flocked from all parts of the world to be present at the opening of the Flavian Amphitheatre; games were celebrated for 100 days, during which time 5000 wild beasts were slaughtered. In the reign of Trajan, an entertainment was given that lasted 123 days, 2000 gladiators successively appearing on the arena. Amongst the strange animals mentioned as taking part in the show, are ostriches, zebras, lions, leopards, elks, giraffes, elephants, and even the rare hippopotamus, who probably met with a less agreeable reception than amongst the novelty-hunting fashionables of our metropolis.

The games of the Amphitheatre was the last remnant of Paganism that gave way before the dawning light of Christianity; they were not abolished till the fifth century. Gladiatorial combats were put an end to by the courage of the monk Telemachus, who rushed upon the arena, and endeavoured to separate the combatants; he was instantly torn to pieces by the brutal populace, but the heroic deed roused the Emperor Honorius to exert his authority in repressing a spectacle so obnoxious to the religion he professed. These shows ceased from that time, but fights with wild beasts continued to be exhibited till the reign of Theodoric (523 A.D.) Since then, the Coliseum has fallen into disuse, and was long a prey to the spoiler, till it was consecrated by Pope Benedict XIV., who erected the cross that now stands in the centre. There is a prophecy relating to this building recorded by Venerable Bede: "As long as the Coliseum stands, Rome shall stand; when the Coliseum falls, Rome will fall; when Rome falls, the world will fall."

There are remains of four other amphitheatres—those of Verona, Capua, Nîmes, and Pola in Istria; these are all similar in plan to the Coliseum, though of smaller dimensions. That at Verona is

of rustic work; the piers between the arcades are decorated with pilasters. The amphitheatre at Nîmes has two stories of the Doric order. That at Pola differs from the others in being situated on the slope of a hill, so that nearly one-half of the ellipse is on a more elevated plane than the rest; the basement and first story on that side are suppressed, and most of the seats are supported by the natural slope of the mountain. This building consists of three stories above the basement, which is of rustic work, strengthened by buttresses and surmounted by a cornice; in this part are several square doorways. The first story has Doric pilasters, without bases, but resting on pedestals, and with a rustic entablature; the second story is similar, but the piers are sligher, and the pillars rest on a continuous stylobate, or subbase; the third story is an attic, perforated by square windows, one over each arcade. The curve of the amphitheatre is interrupted by four projections, each of the width of two arcades, containing staircases.

Besides the amphitheatres, the Romans had Naumachia, in which the central area was filled with water for naval combats; and Circi for horse and chariot races. The Naumachia of the Emperor Augustus was 1800 feet long by 1200 feet broad. The Circus was of the same form as the Hippodrome of the Greeks; but the seats, instead of being laid out on the natural elevation of the ground, were raised on arches like those of the amphitheatres. There were several circi in Rome; the principal was that known as the Circus Maximus, founded by Tarquinius Priscus. It was much enlarged and improved by different emperors, and offered accommodation for no less than 485,000 spectators. The two Egyptian obelisks now seen in Rome, formerly stood upon the spina of this circus.

The Theatres of the Romans so closely resembled those of the Greeks, that a detailed description is unnecessary; the greatest differences were, that all the performances took place on the stage, the orchestra being the place where the senators, and other persons of distinction sat; and that they were built on level ground, the exterior presenting several stories of arcades, like the buildings already described. The first permanent theatre in Rome was erected by Pompey the Great. The Theatre of Marcellus was built by Augustus, in memory of the son of his sister Octavia; this was of two orders, Doric and Ionic, and was sufficiently large to contain 30,000 spectators. At one time there were as many as three thousand singers, and three thousand female dancers, engaged in the theatres of Rome; and during a severe famine, when all strangers, including artists and professors, were banished from Rome, these alone were exempted—so necessary had the amusement they afforded become to the luxurious and pleasure-loving Romans.

The great Thermae, or public baths, also strikingly displayed the prodigality and magnificence of this people; indeed, some of the descriptions of these places more resemble the inventions of romance than sober matter of fact. The vast halls were supported by elaborately wrought columns of foreign marbles, and decorated with the finest works of the sculptor; the walls enriched with fresco painting and gilding, and the pavements composed of beautiful mosaic work; candelabra of bronze or gold, of exquisite workmanship, shed from their lamps a softened light through crystal globes; and the rarest perfumes floated on the air. Besides bathing-rooms, these buildings contained libraries, gymnasia, exedrae for conversation, and, in short, everything was assembled under one roof that could contribute to the health of the body or the recreation of the mind. In the time of the Commonwealth, the public baths were extremely simple, consisting of a few obscure chambers, with small openings in the wall instead of windows, the belief prevailing that darkness helped to retain the heat. It is said that the refined descendants of an Etruscan King—Mucius—first introduced the thermae in their improved state into Rome; in aftertimes there were no less than eight hundred public baths in the imperial city alone. The thermae contained seven principal descriptions of rooms for the convenience of the bather—the Apodyterium, a sort of dressing-room, furnished with tables and shelves where the bather might deposit his clothes, which apartment was also called the Spoliatorium; secondly, the Unctuarium, a small chamber where oils and perfumes for anointing the body were kept; thirdly, the Sphaeristerium, where exercise was taken to open the pores of the skin before entering the bath, and where a kind of game was played something resembling tennis; then followed the Frigidarium, or cold-bath, which room was generally exposed to the north, and contained various vessels for washing; next, the Tepidarium, placed between the cold and hot bath; and beyond, the Caldarium, which was the most frequented, and

was situated immediately above the hypocaustum or furnace. The bath was constructed of brick or masonry, lined with cement, and having a margin of stone; the bottom inclined so that the greatest depth was in the centre; it had a flight of steps leading down into it, and was surrounded on three sides by a balustrade, to divide the bathers from those who were waiting their turn; the windows were placed high, so as to prevent the apartment from being overlooked from without; some of the halls were without windows; and were lighted by candelabra both by night and day. The last room contained the Piscina, or swimming-bath, which was, in some of the thermae, of such an extent as to be a complete lake of warm water; this constantly flowed in through a brazen pipe, the convolutions of which passed through the furnace. The piscina was sometimes elevated, so that the prospect might be enjoyed while swimming about; it was then called Balnea pensile. Another kind of bath was generally contained within the building, for the use of invalids; this was the Laconicum (so called from its having been used in Laconia), or Concamerata sudatio; it was close to the furnace, and was a small chamber with a domical roof, in the aperture of which was a brazen shield, which was raised or lowered to regulate the temperature; round the chamber were niches called Sudationes, where the bathers placed themselves; this kind of dry bath was much used by aged people. There is much uncertainty as to the mode of heating the quantity of water required in these great thermae; but the water appears to have flowed from the castella, or reservoir supplied by the aqueduct, into vaulted brick chambers, over the furnace. As the water was drawn off in a boiling state from the last chamber, it was replenished from the next, only a few degrees less heated, so that the heat was never checked by the admission of cold water. The wealthy had private bathing apartments in the great thermae, where the baths were made of copper or porphyry; many such have been found.

The most celebrated thermae in Rome were those of Titus, Caracalla, and Dioclesian. The Baths of Titus are supposed to occupy the site of the more ancient building of Mæcenæ; here were discovered those beautiful frescoes from which Raffaele himself did not disdain to copy. In order to preserve these paintings from being injured by the splashing of the water, the walls for ten feet of their height are incrustated with coloured marbles. The Baths of Caracalla contained fifty halls and sixteen thousand marble seats; four grand staircases led to the upper story, where the apartments for exercise and conversation were situated: 288,000 cubic feet, or 1,800,000 gallons of hot water were distributed through these baths every hour. In one of the great halls of the Baths of Dioclesian is the only existing example of the use of the Corinthian and Composite orders in the same apartment: there are four Corinthian columns at the angles of the hall, and four Composite supporting the vault in the centre; the shafts are of granite, the capitals and bases of white marble. From the ruins of the different thermae have been dug some of the most valuable works of art; amongst the rest the Laocoon and the Farnese Hercules.

Triumphal Arches are undoubtedly of Roman origin, no records existing of any such structures before the time of the Commonwealth. It was an old custom in Rome, to honour the victorious generals with a Triumph on their return from foreign conquests; on these occasions temporary arches of wood, decorated with festoons of laurel and flowers, and trophies of war, were erected over the Via Sacra, the road they passed along on their way to the Capitol. On the arch were stationed musicians, and a figure of Victory so contrived as to drop a wreath on the head of the conqueror as he passed beneath; this is the origin of the figures of Victory holding out a wreath, sculptured on the spandrels of the arches. Those who had been honoured with a triumph, were naturally anxious to perpetuate the memory of such an event; and to this end caused the temporary wooden arch to be replaced by one of stone.

The triumphal arches erected during the Commonwealth were (judging by the representations on ancient coins) simple and unadorned, save by a commemorative inscription; but under the Empire, they, like every other kind of building, were elaborated to the utmost that wealth and a sumptuous taste could devise; and as the decorations and inscriptions recorded the events that led to their erection, they are not only admirable for their beauty, but valuable as histories carved in stone. The earliest in date now remaining is the Arch of Titus, erected by the Emperor Domitian to record the victories of Titus over the Jews. This structure consists of one archway, with an attic supported by four engaged Composite columns on each front. The columns at the angles are returned on the flank, where they have a greater pro-

jection than on the front—they project nearly half their diameter; the two columns on each side the arch stand on a continuous pedestal. The opening of the archway is an exact square to the springing of the archivolt; the entablature is one-fourth the height of the column, and the attic nearly half the height of the order. The whole is constructed of large blocks of Parian marble; one of the stones of the cornice is 10 feet in length; the architrave and frieze are in one block in height; the arch is composed of eleven voussoirs; the blocks were originally fastened by metal cramps, most of which have been removed. The archway is adorned with bas-reliefs, representing the conquests of Titus in the East; one of these is particularly interesting, the subject being the sacred utensils, candelabra, &c., belonging to the Temple at Jerusalem, borne in procession at the Triumph of Titus.

The arches of Septimius Severus and Constantine, consist of three openings, the central one being the largest; they present a similar façade on each front, having four detached columns, backed by pilasters resting on the same pedestals as the columns.

In the Arch of Septimius Severus, the arches communicate with each other by cross openings. The detached columns have been objected to, as having nothing to support, and therefore being useless; the two inner ones are not even surmounted by pilasters on the attic. The statues placed on the entablature remove this objection in the Arch of Constantine. The Arch of Septimius Severus is of the Composite order, and is 76 ft. 4½ in. in height, by 68 ft. 2½ in. in breadth; the columns are ten diameters in height. The openings are lofty; the centre one being nearly, and the side ones quite, double their width up to the springing of the arch. It is richly decorated with bas-reliefs, and had formerly a triumphal car on the summit, with statues of the emperor and his two sons.

The Arch of Constantine is made up of parts carried away from other structures, which the architect has not even known how to apply properly. No artist was found in Rome capable of executing the bas-reliefs; they were therefore most inappropriately borrowed from the Arch of Trajan, the subjects setting forth the conquests of the latter emperor, instead of those of Constantine. The structure altogether presents a curious mixture of two different periods, and of the best and worst taste. Amongst other incongruities it may be remarked, that the cornice of the impost has both dentel band and modillions, while that of the entablature has modillions without the dentel band.

Besides the Triumphal Arches, properly so called, there are many, either simply commemorative of some person or event, or serving as ornamental gates to a city: such are the arches of Gallien at Rome, of Hadrian at Athens, and of Trajan at Ancona. Speaking of the Arch at Trajan, Serlio says, "those who understand art, are not only delighted with the admirable intelligence shown in its construction, but render thanks to the architect for having produced a work by which our age may be instructed, and may discover the rules of the beautiful." This arch is small, being only 9 ft. 10½ in. in width, but lofty; it is more than twice its width to the springing of the arch. On each front are four Corinthian columns; it is erected on a basement; a bust of the emperor is sculptured on the keystone; and the spandrels and walls between the columns were formerly decorated with bronze ornaments. It was built 116 A.D.

We have now passed in review the principal public buildings of the Romans; and in the next Lecture, I propose to inquire into the Domestic Architecture of this great people, though comparatively little is known on this subject, owing to the few remains.

LIST OF AUTHORITIES.

Vitruvius—De Re Architectura; Gibbon—Decline and Fall of the Roman Empire; Gibbon—Architectural Antiquities of Rome; Taylor and Cressy—Les édifices antiques de Rome; Desgodetz—Architectures; Palladio—Architettura; Serlio—Encyclopédie Méthodique—Ancient and Modern Architecture; Gailhabaud—Fabrique antiche di Roma; Cipriani—Verona illustrata; Maffei—Antiquités de Nîmes; Clerissau—Maison de Titus; Ponce.

DEVONPORT MECHANICS' INSTITUTE.

THE great town of Plymouth, Devonport, and Stonehouse, is well supplied by the liberality of its inhabitants with libraries and institutions. We lately described an institution at Plymouth, and we now bring before our readers the design for the extension of the Devonport Mechanics' Institute, carried out under the direction of Mr. Alfred Norman, architect, practising in the town.

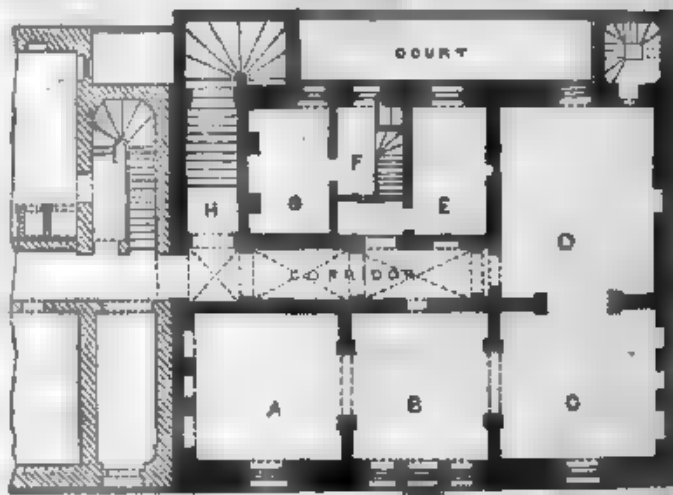
The engraving shows the front towards Duke-street, which, on the ground-floor, is surmounted by an entablature of the Doric order, and is constructed of Portland stone. Above this ground-floor are two rows of windows, the lower being smaller, and a kind of base to the upper row. They are designed to give light to the

lecture-hall and galleries. The elevation, it will be seen, is terminated by a cornice, with projecting brackets and eaves roof. There are three windows in the width, and the middle one on each floor has three openings. On the ground-floor this centre window has its openings formed by two Doric columns, the shafts of which are rusticated, in correspondence with the quoins forming the dressings of the side openings, and of the two other windows. The cornices and consoles of the lower part of the middle range of windows support the balconies and balustrades of the upper range. In the upper range, the middle window is converted into an arched Venetian window, with the central opening of which the window-head on either side corresponds, having a richly-moulded arch-head and ornamented keystone. The dressings are of Portland stone, and the rest of the work of limestone rubble, faced with Portland cement.

The interior contains upon the ground-floor a library, 60 feet in length by 15 feet in height, and which may be converted into three rooms, connected by two large open arches. The end or side divisions only are for books, the middle one being used as a museum. On the ground-floor are likewise a class-room and some officers' rooms. The upper floor is occupied by the great lecture-hall, 61 feet by 46 feet, and 30 feet high, lighted by a double range of windows. In the hall are likewise galleries. The ceiling is divided into compartments by carved beams, and the walling is finished with an enriched frieze, cornice, and cove. One large central ventilator, and two smaller ventilators, are made ornamental. The building was finished in the spring of this year, and the whole cost was about 2200*l*.

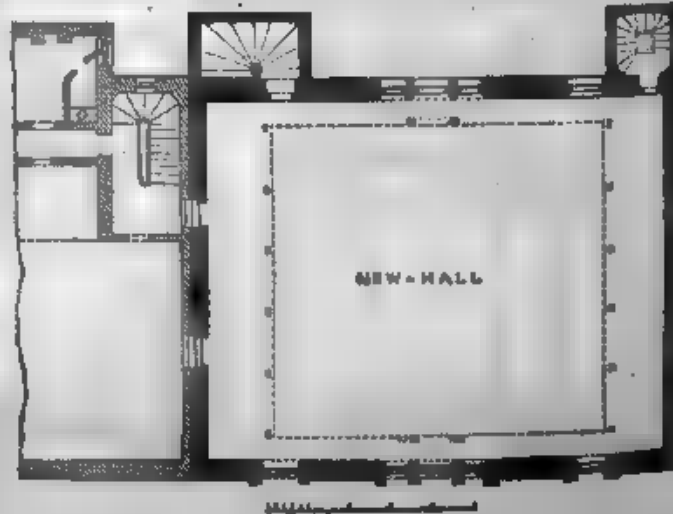
GROUND PLAN.

A, Library; B, Museum; C, Library; D, Class Room; E, Parlour; F, Staircase, and Scullery under; G, Kitchen; H, Staircase leading up to the New Hall.

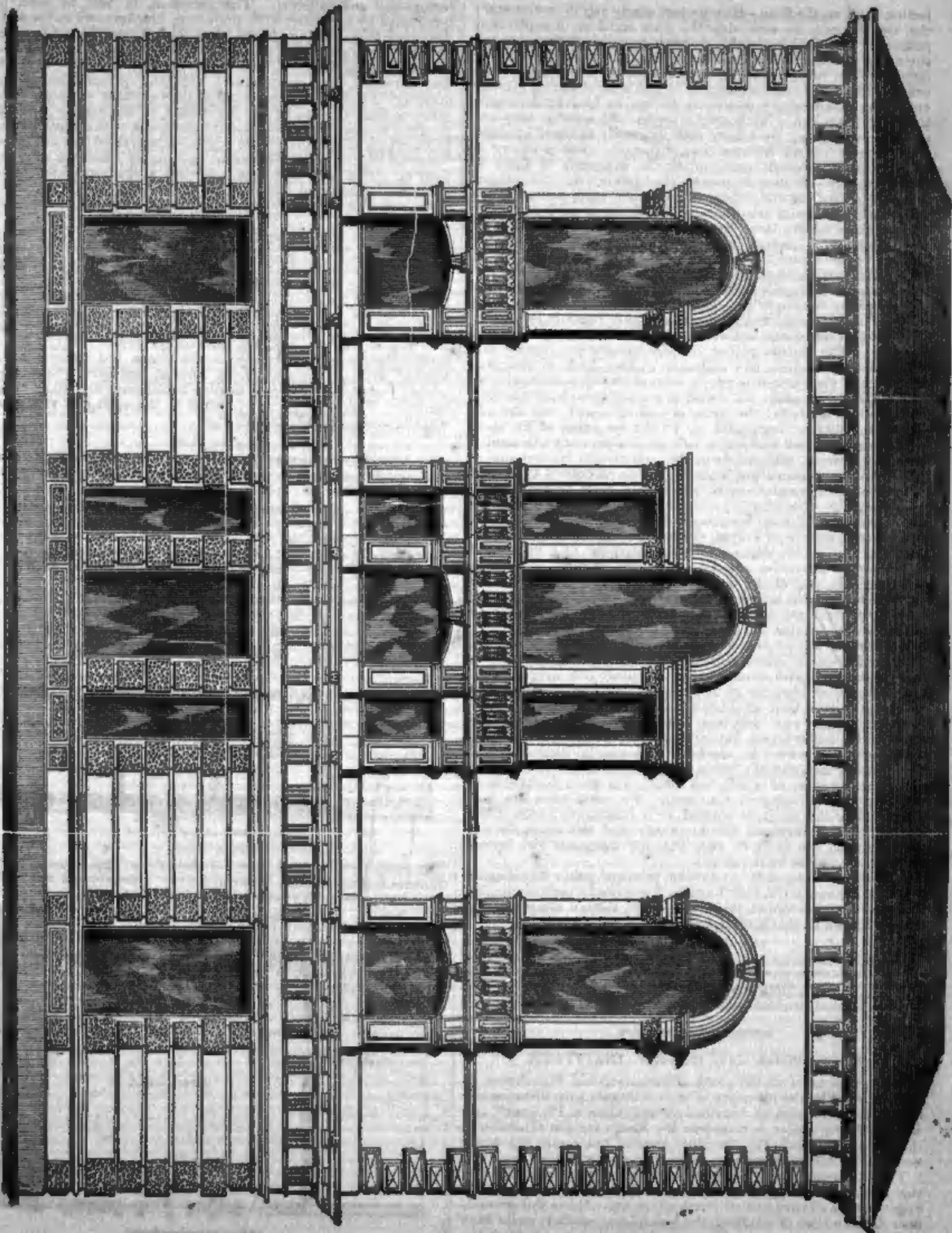


UPPER PLAN.

Contains the New Hall, with a Gallery above. The situation for the Lectorer is at the Window between the two Staircases, and that for the President opposite. The part not tinted is the old building.



DEVONPORT MECHANICS' INSTITUTE.—Mr. ALFRED NORMAN, Architect.



ROMANESQUE ARCHITECTURE.

A few Remarks on some of the leading points of Romanesque Architecture. By JAMES ENNESON, jun. (Paper read at the general meeting of the Architectural Association, Lyon's-inn Hall, 18th October, 1850.)

It has not been by any means the chief aim in the subsequent remarks, to enter into an historical or antiquarian account of the rise and development of those architectural forms exhibited in the early ecclesiastical architecture of Italy, and which usually pass under the name of Romanesque, any further than is necessary for the sake of distinction and elucidation. It is, on the contrary, I believe, often desirable to escape as much as may be from all influences which are not to be found in the art itself; to think upon, and to view it for instruction and guidance, as architectural students; believing that such inquiries as we have alluded to, too minutely followed out, are more proper to the antiquarian than the architect, and that they too often, to the great loss of the student, carry away the imagination, and blind the vision to those real and lively principles of the art which ought first to claim his attention. It is, nevertheless, necessary to trace the development of succeeding forms and arrangements—their origin and progress; because, in tracing the growth of the first rude attempts to the latest perfection, the architect learns to understand the inferior stages of development, and wins his way to the better starting point for his own exertions, sees that progress and onward movement is the very soul and life of his art, and receives by the study a mental discipline and correction that trains his own mind for vigorous exertion, and helps him to throw aside fearlessly the trammels of conventionalism and fashion.

It has always seemed to me that the study of those architectural efforts called Romanesque is, to all these ends, useful and well fitted; it is simple and vigorous, determinate and striking; bold in its effects; with all its simplicity, very often artist like; often mistaken, yet the production of no paltry and flimsy tone of mind, but the solid expression of real wants, deeply felt and fervently put forth.

It is again an especially interesting study if it is allowed—as to me it appears that it should be—that it shares with the Byzantine the parentage of all the later styles, Christian and Mohammedan; and without staying for one moment to inquire into the vexed question as to whence the Pointed arch arose to work its mission of revolution in the architectural world, I will claim this fact for the Romanesque, that it was through it that society, under its much changed and altered conditions, shook off those chains that bound the art to Classic models; and that it adds one more bold unanswerable witness of the fact, that *progress* is the life-blood of architecture; for that age—glowing freshly with the first benign influences of Christianity, and daring to throw aside the beautiful forms presented by the Pagan world—thinking and acting for itself, led the way to those delightful creations of the later Gothic school; and has thus earned the respect of all subsequent ages, and deserves well of all lovers of architecture; well merits the student's careful attention, and cannot fail to reward him plentifully for the industry he may bestow.

Last any one should think, by the passing allusion above to the pointed arch, that I suppose it invented by Romanesque architects, I will simply record my belief that, like the circular arch, it was known, and occasionally by chance was used, much earlier; that the Arabian architects used it first as a general feature, but that for the Gothic architects was left the enviable task of evolving the true principles which it contained—of working it out and bringing it to its highest perfection.

In passing, I cannot help observing the great advantages which architects of these later times have over their fathers; the architectural expressions and knowledge of cycle on cycle of the world's efforts in the art, is laid before them for their instruction by innumerable careful and talented works on the several subjects; and the architect, in a few years, and in his own studio, may learn more than he could formerly have learnt in as many lifetimes. Oh! surely these advantages should never be abused to the stultifying and annihilating of his own intellect and genius; but ought, on the other hand, to be so many powerful incentives to his fresh exertions—nourishment to strengthen his imagination for renewed efforts—beacons to show him the rocks to be avoided in his course—pinnacles of ambition which he may reach, and from which he may see a yet unattained world of beauty beyond.

By Romanesque, then, I understand that style of architecture which was used after the decline of Roman power, and the removal

of the seat of government to Byzantium; and which continued until the use (I will not say the discovery, but until the use) of the pointed arch led the way to the entire change in Christian architecture—till what we call Gothic became prevalent in Italy, and long after it was generally used in other countries; extending, as to time, therefore, from the middle of the fourth even to the thirteenth century, for Pointed architecture obtained no certain footing in Italy till after that time. The locality in which this style prevailed was confined to Italy—that is, North Italy and Lombardy, and is very distinct from that architecture very properly called Byzantine, which was the work of Greek architects, of a much more oriental character, and with many distinctive marks; having, in fact, Greek architecture for its basis, as Romanesque had Roman on the one side, and the early German Gothic—which, in many respects, appears akin, but is nevertheless very different—on the other. The distinctions between the churches in this style are chiefly between those built at and near Rome—which was for ages a great quarry, from which were taken not merely stones, but parts of buildings, columns, cornices, &c., to be worked up whole into other buildings (and they therefore partook more of the old classic models)—and those Lombard edifices, and others, at a distance from such assistance, and which are therefore more defined in style, and give clearer evidence of a step or two towards the Gothic.

First, then, let us consider the *plans* of buildings in this style: the earlier ones are found in the great majority—perhaps in all cases where Pagan architecture was employed—to be exactly that of the ancient Basilica, or hall of justice; that is, a parallelogram, or nearly a double square, with the semicircular or octagonal recess at one end, usually called the *apsis*—in the court-house, the judge's seat; but in the church, the sacred place where the altar was placed, and round which sat the bishops and presbyters. In some examples the atrium adjoining was retained, as at San Clemente near Rome, and San Ambrogio at Milan; and which, in appearance at all events, would appear to bear some analogy to the more modern cloisters. In some of the later edifices we observe the transeptal arms broken out, as in a Gothic cathedral; but by far the most usual is the simple Latin plan—though we do, in some instances, see some examples of the Greek cross; but these must, in all cases, be put down as the work of Greek architects, for the Latin architects never altered the more ancient form to which they were accustomed. And I think, beyond all question, this simple plan, so much preferred by the early Christian church, may be traced through the Romanesque to the Gothic; and that there can be no doubt but that it was the excellent basis which lies at the root of all the variations which that style engrafted upon it. This form of plan was used by the early Christians, doubtless, because in many cases they found it ready presented before them in the already existing basilicas, which they easily converted into churches; and secondly, because its simplicity was admirably adapted to their wants—the central nave and two side aisles: the northern assigned to the women, the southern to the men; the centre occupied by the choir and sub-deacons, then by the neophytes and candidates for baptism; and lastly, near the door, by the penitents.

True, we find this simple plan extended and added to subsequently, though always preserved as the main principle of arrangement, particularly in the neighbourhood of Rome; and those alterations which did take place, as the addition of transepts, &c., are much the most usual in Lombardy. The single *apsis* was never forgotten; but others were added at the end of the aisles, then to the transepts; and as the fashion of building chapels to tutelary saints became more in vogue, they were even broken out laterally. In all the earlier instances the floor was level, except only two or three steps to the *apsis*, where the high altar was situated; but as the prejudice against burial within the consecrated walls died away, and as the Church began to build for itself, we find the introduction of a new feature in the plan, and which is treated with the utmost importance—the *crypt*, which in these edifices appears not as a place of sepulture, but as a sort of lower church, complete with its altars and shrines; supposed by some to have been erected in imitation of the catacombs—those early places of meeting, in which the early Christians were wont to hide themselves, and to carry on their simple but sincere worship. Whether this be a mere fanciful supposition or not, what we know is, that they were prepared for the reception of the bodies of confessors and martyrs; and as such were treated with as much care and attention as the rest of the church—not sunk into the earth, but often nearly on a level with the floor of the nave, and with a number of steps ascending to the choir above (which had then been removed from its first position in the nave), just as we see it

at Canterbury: it is thus at San Miniato at Florence, and at San Flaviano near Montecasale, where there is a complete lower as well as upper church; at San Francesco at Assisi, where the great St. Francis was entombed; at San Zenone at Verona, and many other places.

This custom of building crypts and subterranean chapels was continued in the architecture of our own country until the last half of the eleventh century, but probably not much later.*

Considering these churches in section, we find in the earliest examples, arches springing from the capitals of the columns between the nave and aisles, and carrying a clerestory; the roofs in all cases of low pitch, of wood, with level tie-beams; the trusses near together, and the side-roof generally of less pitch than that over the nave, just as we usually see it in our own parish churches. The flank walls at first flat, till in the church of Santa Maria at Toscanella, erected in the seventh century, we find them relieved by piers and arches projecting from the face, and as if forming recesses in the wall ready for ribs and cross springers, but with the groins left unexecuted. In the church of St. Agnes near Rome, built a little later, we have another step in advance, for the clerestory is raised higher, the aisles are groined, and over them are galleries, with a second series of columns and arches over the nave columns, with a balustrade between, forming excellent and spacious galleries; being an arrangement in this style precisely similar to that of our own cathedrals with their triforia. The aisles, although groined under the galleries, are, with the rest of the church, roofed above with wood, which again reminds us of a practice usually followed by the Gothic architects. These galleries, most probably, were for the use of the women, as the triforia have been conjectured to have been used by the nuns. In the Cathedral of Pisa, built in the latter part of the eleventh and beginning of the twelfth century, we find this arrangement magnificently treated, and with a still nearer approach to the Gothic treatment, for the piers are carried through and within the larger arches; springing from one pier to the other, are again two smaller arches, with a column in the centre. The proportions of this cathedral are noble and lofty, the galleries spacious and most effective features. The aisles are double, divided with a range of columns down the centre; they are groined, but the roof is of wood, as in the former examples; and here we find very successfully introduced the alternate courses of red and white marble, a fashion just then obtaining—here confined to a cross in the spandril between the nave arches, and to the striping of the clerestory and projecting ribs of the groining. The good taste of this practice is much questioned; but it has certainly here received the sanction of a masterly mind, for such must have been the architect of this cathedral. It seems to me, that care bestowed in arranging the different materials in a building as to colour, is admissible, and capable of adding much to the good effect—though much overdone in some of these examples.

It can hardly be well used over the whole of a large building—it is much better confined to parts which can be easily taken into view at once, and is, I think, particularly applicable to circular work of any kind. There is a great defect to be remarked in the groining of the aisles in this cathedral, inasmuch as the springing is considerably above the cap of the central column, so that there is first of all a sort of pier above the cap, which gives an appearance of great weakness; but even at this later period, we find the earliest model was not entirely deserted, for at San Zenone in Verona, built in the twelfth century, there is no triforium or gallery; but a magnificent effect is got by the well-proportioned simplicity of the design, and by the alternate piers and columns between the nave and aisles. In this church, alternate layers of marble and brick are used.

In the Cathedral of San Francesco at Assisi, erected in the thirteenth century, built by a German architect, we find the first example of any importance of the introduction of the pointed arch in Italy. From this time it became always used, with more or less mixture of the now declining Romanesque; the effect of which is particularly evident in the fine Cathedral of Siena; in which we have the pointed arch with the mixture of Classic details, cornices, consoles, capitals, &c., the walls being composed of layers of white and black marble.

The whole of the interiors of these churches were lavishly decorated with fresco, mosaics, &c. A great difference is, however, observable between the style of decoration which was followed in the Lombard churches of Northern Italy, and those nearer Rome. The former are remarkable for great stiffness of

design, very gross imagery, grotesque carvings and ornaments, all crowded and buddled together, the foliage bearing some analogy to our own early Norman, and by no means equal to the Byzantine of the same date. The latter are much better in arrangement and drawing; their excellence, however, is only comparative.

In the earlier Romanesque churches, the exterior effect would seem to have been deemed of an importance altogether secondary to that of the interior, presenting often little else than bare walls, with few and ill-arranged openings. After a while, however, we find these made more important, and the exterior walling broken into piers and recesses, particularly the apses, which were decorated with long narrow three-quarter columns running up to the eaves. But a much more decided attempt to gain an effect is made by the introduction of arcades or passage-ways in the thickness of the wall, particularly round the apses, immediately beneath the eaves, as if for a passage-way from one gallery to another, without the necessity of entering the body of the church. This is the case with two of the churches at Pavia, San Frediano at Lucca, a church at Arezzo, &c. The Cathedral of Pisa has an arcaded facciata of no less than four tiers, as also has San Michele at Lucca, and Santa Maria at Arezzo. These arcades might, perhaps, have been used as a sort of cloisters, though hardly very much retired; and, from their elevated and commanding situation, much more calculated to enliven and delight him who walked therein, than to lead his mind to those quiet and abstract contemplations which would be more congenial and suitable.

If not for some practical purpose of this kind, I am unable to determine what may have been the use of this oft-repeated feature; where sparingly used in the towers and apses it is very effective, but in some of the examples above cited, it would appear to be overdone—to be made too distinctive, so that the outer wall is made nothing less than a screen to an inner one; whereas, if treated as part of the external wall, the relief thereby given to it, and the solid effect, the depths of shade, and points of bright light, conspire together to assist the effect of the whole very advantageously.

In the façade of San Pietro at Spoleto, we have an instance of a style which has been very aptly called the "Cabinet Style," a style which I think has never wholly become obsolete, but is occasionally followed even in this day. It may be called the climax of un-architectural effect. Bad proportions, bad arrangements, and bad construction, are all, of course, un-architectural; but still a building, with all these faults, may have more of the architect about it than a building in the style now alluded to. It may have what this style really wants—some leading idea and purpose, some fine and poetic notion, even let the result fall never so far short of the achievement it proposed to reach. Here we find a nearly equal surface for the façade, with certain square lines ruled upon it across each other, so as to form the most prim and severe-looking panels; in them are set certain circular windows, doors where needed, and surrounded by a profusion of laboured ornament and decoration; each part utterly discordant with the rest, and the whole very ingenious, but telling most significantly of efforts painfully abortive, as far as regarded anything good in the ultimate effect, being after a manner which would be much more suitable to the inlaying of a work-table, or any other similar piece of furniture, than for a work of art of a nature so much more exalted as Architecture. And the architect who neglects truthfulness, who seeks to hide construction, who fears too much to show the anatomy, so to speak, of his design, is in great danger of falling into such a style as this.

What, then, beyond the mere appreciation of detail and general arrangement—or vice versa, the lessons to be learnt from bad detail and arrangement—is the profit to be gained from the careful study of the architecture of that period and country now under consideration? The study of detail is useful; but far more important is it that the student should seek for principles—the principles which lie at the root of all the details and forms which outwardly appear as the results of those principles; growing upon them, and the whole succeeding or failing, as the first basis is justly founded or not.

Now, in this style we observe the transition from the Classic to the architecture known as Gothic—that is, from a mode of treatment the whole life and soul of which is contained in the successful application of lengthened horizontal lines, and of figures bounded by such parallel lines, to another mode of treatment whose very essence is contained in the like use of lengthened vertical lines, and of figures bounded by such lines. This being a style of transition—for the Classical treatment was wholly unsettled by the use to which the circular arch was put in this style, and so

* In the discussion which followed, St. Leonard's, York, a church at Madley, Herefordshire, and Hereford Cathedral, were mentioned as having crypts of a later date.

yet the great principles contained in the pointed arch lay dormant,—we find a mixture of the two principles; and to this we may attribute that unsuccessful and unsatisfactory effect which, notwithstanding the good points we have been able to allude to, generally marks the style: and it is well worth the trouble of a patient study, if we may demonstrate from these examples that any conjunction of these two principles, so perfect in themselves when kept apart, cannot succeed—that they will not assimilate.

In these times, when, happily, there is a desire and purpose abroad to escape from copyism, and attempts at positive reproduction, it is of the utmost importance to determine what may and what may not be attempted with a fair chance of success; and in the study of earlier styles to this end lies the great advantage—of consequence infinitely greater than the minute differences in the contour of a set of mouldings or the style of foliage, decoration, or indeed anything else subordinate to the great radical principles which must lie at the bottom of the superstructure of ideas, even though, perhaps in great part unsuspected by those who set up the edifice of mind and taste.

In all the earlier history of Architecture, in all countries and in all ages, we find that it is the natural offspring of the social condition, circumstances, and bias of each nation, and the strong expression of those feelings and tendencies which had most weight and were the most prominent features in the national character. Nothing, indeed, could be more natural than that it should be so; for whether a nation would express the glowing fervour of religious enthusiasm, or the towering pride of warlike ambition; whether the voluptuous luxury of careless ease and inaction or the chaste and pure breathings of a lofty philosophy and elevated poetry—to what can it fly more suitable to express and show clearly to the world such marks and features? to what, in the range of art, so capable as Architecture to bear such impressions, and to proclaim them intelligibly to all beholders? Thus was it in Egypt and Greece. Had the social state of the Greeks been less highly polished and refined, their intellectual culture less, and their religious feeling more, should we have had their architecture? Had the fervid and enthusiastic, yet exclusive and predestinating, religion of Mahomet found no followers, should we have had the quaint but poetical Moresque? Or, turning to the delightful and refreshing picture of mediæval art, from whence should we derive its peculiar and individual expression but from the pure and holy standard of the Christian religion? the whole overflowing with a loftiness and aspiration of ideas which was never previously seen—was never called into existence—simply, because then, for the first time, had those particular stimulating necessities arisen; the fountain of thought then bubbled up from another region, flowed down from a different source, and nourished a different landscape into beauty and loveliness.

The characteristics of this age in our own country, in a secular point of view, are the luxuriousness and magnificence produced by the influx and accumulation of increasing wealth in individuals and noble houses; a rapid spread of invention and scientific discovery; great and increasing national power and resources; a peaceful industry and love of peaceful arts, but an energetic resistance of all aggression; a great pride of country and love of home; and desire for national pre-eminence, to be gained rather by solid institutions and sound government than by force of arms or political intrigue and chicanery. If Architecture, then, had been allowed to have the guidance of its own natural laws of progression, it might be perhaps supposed, with some show of reason, that a national style would have grown into strength and beauty; which, preserving the treatment peculiar to the mediæval styles, would yet have been influenced by the refinement of the Greek, tinged to some extent with the ornamental profusion of the Roman: a style bold and massive, resting for its effects upon solid proportions rather than upon detail—most likely with a leaning towards the pier and arch treatment rather than to the columnar; different from all that had come before, and as English as our ships, our laws, or ourselves.

Yet, should such a thing ever come to pass by the lesson before us, we see that it never could be done by any incongruous mixture of old examples and styles. What we must look for to realise any great change is some new principle—some great main idea; and should such be discovered, then, without difficulty or effort, we should have a new and national style. Till then we may rest assured that the great principles already known to us admit of many applications different from those that have already appeared, and which will doubtless reward a patient investigation. And we shall do well to abstain, not merely from copying, but from gaining originality by any slashing mixture of old styles: the result may

very possibly be quaint, perhaps with some merit; but could never become a style, and never be beautiful, because always imperfect.

I think we may also receive some instruction relative to that which is an important consideration in modern church architecture—namely, how to introduce galleries.

It is very generally conceded that in our crowded cities, it is impossible to keep galleries out of our churches; and, indeed, I know not why it should be thought desirable to do so, for in a Protestant church, where hearing quite as much as seeing is the requisite, it is a ready means of bringing a great additional number within the required distance. I believe, if treated as a mere piece of cumbersome furniture, a mere stage put up without connection or any harmony with the rest of the building, that it must always be wholly unsuccessful and unarchitectural. If, however, treated as in some of these churches (St. Agnes, for example), there is no such objection—no such fault to find. In a Gothic church, put—as we usually see it—where it ought not to be, it is obtrusive and unpleasant. In a church of Classic design—as we usually see it—it has the appearance of an inharmonious erection in a disproportioned room. But only let it be above the arches between the aisles and nave; only let the lines of the nave be continued up to the roof, the gallery not interfering with it—and the whole is compact and proportionate. The beauty of the Basilica plan, whether applied Gothically or Classically, is the just proportion between the aisles and nave—the unbroken height of the lengthened vista, and the effect, is wholly lost if all be thrown open together on the one hand, or choked-up with carpenter-like contrivances on the other.

I doubt not, with a little care, galleries might assist the general effect, instead of the contrary, as at present; and still retain their acknowledged qualities of usefulness and saving in expense.

MR. STEPHENSON AT BERNE.

THE Swiss Federal Council have certainly pitched upon the best expedient for settling the important question of their system of railways, by calling Mr. Stephenson to a sort of professional consultation. Mr. Stephenson, accompanied by his assistant, Mr. Swinburn, had the whole mass of plans, sections, and estimates laid before him, as well as statistical tables relating to population, the amount of traffic, &c. The English engineers, accompanied by M. Counsellor Naff, have also made a tour of inspection through the east and middle of Switzerland, and are about to proceed to the new projected lines of the west. As far as the opinions expressed by Mr. Stephenson have become known, they are as follow. He does not think it advisable to cover the whole of Switzerland at once with a network of rail, but to begin rather with a few central lines, which would bisect the land from east to west, and north to south. These are to be undertaken by the federal government; while the branch lines, which have subsequently to connect those main arteries, are to be executed by the single republics (cantons).

Mr. Stephenson has been gratified by the geological fact, that in the direction contemplated (that of the equator and the meridian), the longitudinal stream valleys of the Alps are favourable to the project, whose rise and fall do in no case exceed 1 in 100.

In a financial point of view, it is Mr. Stephenson's opinion, that the less capital employed, the greater the dividends are likely to be. He proposes, therefore, only single lines of rail; with the avoiding of costly tunnels, viaducts, cuttings, &c., and the accommodation of the line to the most adapted terrain of valleys and the slopes of hills. Further surveys have been made at Hausenstein, according to which inclined planes and compensation engines are to be put in operation at Laufelfingen and Trimbach, and the tunnel of 2500 yards in length, projected by M. Merian, is to be finally executed.

It has not, however, been Switzerland alone which has honoured, on this occasion, the English engineer with particular confidence: the King of Sardinia has also commissioned M. Negralli to meet Mr. Stephenson, for the purpose of consulting with him on the projected new lines over the Albura, the Grimsel, and the Brünig. Mr. Stephenson seems, however, to be altogether averse to the idea of the gigantic tunnel—if anything can be called gigantic because it is impossible. Even the Lukmanier tunnel of 17,000 feet, seems to him an adventurous undertaking, and he prefers the passing of the mountain at St. Maria by means of compensating engines and covered galleries. It is, therefore, easy to foresee what Mr. Stephenson will say to a project, by which the passage from Domo d'Ossola into the Valais is to be effected by a tunnel of one-quarter of a league; that of the Grimsel by one of half-a-league; and the Brünig by one also of one-fourth league in length. L.